A BIOMECHANICAL ANALYSIS OF LAYUP SHOT FROM DIFFERENT FIELD POSITIONS

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CERTIFTCATE

Certified that the thesis entitled **"A BIOMECHANICAL ANALYSIS OF LAYUP SHOT FROM DIFFERENT FIELD POSITIONS"** submitted by me for the award of the degree of Doctor of Philosophy in Arts at Jadavpur University is based upon my work carried out under the supervision of Dr. Papan Mondal, Assistant Professor, Department of Physical Education, Jadavpur University, Kolkata, West Bengal and that neither this thesis nor any part of it has been submitted before any degree or diploma anywhere/elsewhere.

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Dedicated to

MY TEACHERS

AND

MY FAMILY

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INTRODUCTION

"The invention of basketball was not an accident. It was developed to meet a need. Those boys simply would not play 'Drop the Handkerchief."

— James Naismith

1.1 Sports and Science

The prosperity of a nation depends on the health of its people. Because we all know that having good health not only makes us feel happy but also gives us the energy to do our job in the best possible way. That will assist us to make our wealth. Significant achievements in man's life depend on both physical and emotional well-being. And to maintain the well-being sports is the best choice. As a result, there must be a heavy emphasis on sports. We should engage ourselves with all kinds of sports because it keeps us engaged and connects us with other people around us. Sports cultivate a true sense of community and assist us in achieving our personal best every time, whether we are only doing them for fun as amateurs or professional athletes. Many sports require a lot of physical activity (for example, running), and some sports require you to play in a team (such as Basketball). We can enjoy sports recreationally or professionally.

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. In fact, sports in society are so vital that the United Nations (UN) has declared them a human right: "Sport and play are human rights that must be respected and enforced worldwide; sport has been increasingly recognized and used as a low-cost and high-impact tool in humanitarian, development and peace-building efforts." Sporting events have played pivotal roles in communities around the world throughout history. Today, contests pushing physical limits are more popular than ever before. As interest in health and longevity continues to rise, and governments and businesses continue to see sporting events as sound investments, sports will play a vital role in society for the foreseeable future. At no other time in history have sports played such a dominant role in daily life. (nowcomment.com/documents/97820)

Sports, as an integral part of culture, have a significant and beneficial impact on a variety of aspects of human life. Similarly, a society's entire social pattern can be reflected in its sporting achievements. Sports, unlike other activities, do not have a finish line. It is done mostly for the sake of doing it. People play for a variety of reasons, the most common of which is for pleasure, enjoyment or satisfaction. The sport is a career that promotes the coaching of various sports and games, as well as the laws and regulations that regulate them, and it also trains trainees to participate actively in professional sports. It arose from man's struggle to survive in a hostile environment. categories based on the level of participation: leisure sports for children, fitness and conditioning sports for the elderly, and competitive sports for youth and adults. Professional sports are further divided into categories based on the level of difficulty of the competition. The top sport is described as the highest level of competition in which the strength of physical activity causes the athlete's pulse rate to rise to between 180 and 200 beats per minute. Sports have evolved into a scientific discipline as they have progressed. Every country in the world is competing to produce world-class athletes who can win medals in international competitions. With proper coaching, extensive research and development is undertaken to identify various factors that will be productive in achieving high-level success in skills of a given sport (Harrold, 1969).

Some people are born athletes, while others aren't and no amount of science can turn a timid person into a world-class athlete. Many athletes instinctively know how to be the best in their field and that instinctive knowledge, learned through years of trial and error, can yield the same or better outcomes than a theoretical, analytical approach using completely different methods. Usain Bolt isn't measuring how much force his legs will convert into acceleration using Newton's laws of motion as he sprints for the finish line. But understanding a little of the science in our favourite sport can help us build on and achieve more of our natural skills; it can help us run more quickly, swim more quickly, or pull out neater tricks. Sport success is not only the case in science, but also in many other factors such as physical skills, natural talent, endurance, courage and determination (and sometimes much more so). Even science is not fun to play but it adds an additional level to our understanding and helps us to appreciate even more our incredible sporting stars.

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. Science is all about figuring out how the world works by putting ideas to the test. Sport tends to be something new at first glance: hard work in order to defeat an enemy. When you look at sport more closely, it becomes clear that science plays a significant role. The human body is clearly a scientific marvel, capable of transforming a nutritious breakfast into a soccer championship, a world-record-breaking sprint, or a heavyweight boxing championship. But, putting fundamental biology aside, there are many other ways in which sport is influenced by science. Physics, for example, illustrates not only how far a ball can be struck or thrown, but also how quickly a swimmer can cut through the water, how a diver can somersault, and why long jumpers must raise their arms so dramatically as they leap through the air. Let's take a closer look at the science behind a few different sports: ball sports (tennis, soccer, basketball, and so on), track and field (athletics), speed sports (cycling and swimming), and sports that defy gravity and balance (gymnastics).(The science of sport by Chris Woodford)

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. It focuses on application of mechanical physics science principles to understand action movements of human bodies and sports facilities such as cricket bat, hockey stick and javelin and so forth. Sports biomechanics can be indicated as the body's muscular, joint and skeletal actions during the performance of a particular task, skill or technique. The most beneficial effects of proper biomechanics knowledge are on sports skills, performance, rehabilitation, and injury prevention, as well as sports mastery. Hence, we can say “One could say that best athlete is the one that executes his or her skill the best” (Doctor Michael Yessis).

A biomechanical study assesses the motion of a live creature as well as the effects of forces on it. The word "biomechanics" is refer to a combination of qualitative and quantitative elements. The motion characteristics of a human or an item are described using parameters such as speed and direction, how motion is formed by the application of forces both within and outside the body, and the best body positions and activities for efficient, effective motion in this technique. The biomechanical study of various events can aid coaches and athletes in their preparation by revealing the important point of technical performance. The field of biomechanical analysis has received a lot of attention in recent years. The art and science of motion analysis have gone beyond fundamental descriptions of ambulatory patterns to include front-line clinical responsibilities in rehabilitation, surgery, prosthetics, orthotics, ergonomics, and athletics.

One of the most important roles of biomechanics in sports is to aid in the development of improved motor dynamics in both individual and team sports. By assessing motor features and comparing them to data from athletes who have achieved good results in motor dynamics. The conclusions are aided by raw data. If mathematical statistical methods are utilised in the study, the value of these data is raised and the findings are dependent. However, such a method has its drawbacks. The fact that motor characteristics take into account both the effectiveness of the motor process and the current degree of motor skills. As a result, precise criteria are required for evaluating the motor process' efficiency. Such characteristics can be found in almost all sports. They are derived from the large fund of experience of sport practice and they have (in most cases only afterwards) 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. This is true, for example, for the shot-put technique applied first by O’Brien. An essentially better path of acceleration of the shot can be implemented by this technique. Looking at the obvious progress in the development of technique in sports and investigating it more in detail from biomechanical points of view, we generally find starting points for objective criteria in an analysis of the efficiency of motor dynamics. We thus found some starting points for the Biomechanical principle of the optimal path of acceleration in the shot-put technique. More than other sport scientific disciplines, biomechanics must orient to the specifics of sport events if it is to remain productive. This is necessary because motor dynamics themselves are the subjects of Biomechanical investigations. Findings of generally valid levels are, however, only possible to a certain extent because of the differences of motor dynamics and aims of sport events. The degree of coincidence between motor structure and the aim is very important.

1.2 The Game of Basketball

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)

In early December 1891, Canadian Dr. James Naismith, a physical education professor and instructor at the International Young Men's Christian Association Training School (YMCA) (today, Springfield College) in Springfield, Massachusetts was trying to keep his gym class active on a rainy day. He sought a vigorous indoor game to keep his students occupied and at proper levels of fitness during the long New England winters. After rejecting other ideas as either too rough or poorly suited to walled-in gymnasiums, he wrote the basic rules and nailed a peach basket onto a 10-foot (3.0 m) elevated track. In contrast with modern basketball nets, this peach basket retained its bottom, and balls had to be retrieved manually after each "basket" or point scored; this proved inefficient, however, so the bottom of the basket was removed, allowing the balls to be poked out with a long dowel each time. (wikipedia)

Basketball was originally played with a soccer ball. These round balls from "association football" were made, at the time, with a set of laces to close off the hole needed for inserting the inflatable bladder after the other sewn-together segments of the ball's cover had been flipped outside-in. These laces could cause bounce passes and dribbling to be unpredictable. Eventually a lace-free ball construction method was invented, and this change to the game was endorsed by Naismith. (Whereas in American football, the lace construction proved to be advantageous for gripping and remains to this day.) The first balls made specifically for basketball were brown, and it was only in the late 1950s that Tony Hinkle, searching for a ball that would be more visible to players and spectators alike, introduced the orange ball that is now in common use. Dribbling was not part of the original game except for the "bounce pass" to teammates. Passing the ball was the primary means of ball movement. Dribbling was eventually introduced but limited by the asymmetric shape of early balls. Dribbling was common by 1896, with a rule against the double dribble by 1898. (wikipedia)

Throughout the 1920s, there were numerous teams. Hundreds of men's professional basketball teams existed in towns and cities around the United States, with little professional organisation. Teams competed in *guarded* and *husky* dance halls, and players altered from team to team. Leagues were formed and dissolved. The Original Celtics and two all-African American teams, the New York Knicks and the Brooklyn Nets are examples of barnstorming teams. (wikipedia)

FIBA (International Basketball Federation) was formed in 1932 by eight founding nations: Argentina, Czechoslovakia, Greece, Italy, Latvia, Portugal, Romania and Switzerland. The organisation was only in charge of amateur players at the time. Although a demonstration competition was organised in 1904, the men's basketball was first included in the Berlin 1936 Summer Olympics. In the inaugural outdoor final, the United States defeated Canada. In 1946, the Basketball Association of America (BAA) was formed. The BAA and the National Basketball League (NBL) merged in 1949 to establish the National Basketball Association (NBA). In 1950 the first FIBA World Championship for men, now known as the FIBA Basketball World Cup, was held in Argentina. Three years later, the first FIBA World Championship for women, now known as the FIBA Women's Basketball World Cup, was held in Chile. Women's basketball was added to the Olympics in 1976, which were held in Montreal, Quebec, Canada with teams such as the Soviet Union, Brazil and Australia rivalling the American squads. (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. In course of time, it became a popular game in the schools and colleges. Inter-collegiate Inter-university and national championships are being held in this game in several places. Of late, the standard of the game in India has been improved to a great extent. The Young Men Christian Association (Y M C A) College at Madras and National Institute of Sports at Patiala have contributed a great deal to improve this game and popularize it among Indian youth. The women also have taken active part to play this game. (wikipedia)

During conventional basketball play, a team can score a field goal by shooting the ball through the basket that is protected by the other team. If the player shoots from behind the three-point line, the shooting team receives three points; if the player shoots from in front of the line, the shooting team receives two points. After the other team has been assessed with specific fouls, a team can score via free throws, which are worth one point. The team with the most points at the end of regulation time wins, but if the score is tied at the end of regulation time, extra time (overtime) is required. The ball can be advanced on the court by passing it to a teammate, or by bouncing it while walking or running (dribbling). It is a violation to lift, or drag, one's pivot foot without dribbling the ball, to carry it, or to hold the ball with both hands then resume dribbling. (wikipedia)

In every basketball game, the purpose of each team is to throw the ball into opponent's basket and to prevent the other team from securing the ball or scoring. It also implies that the players should be aware of and follow a set of rules that they are willing to work with others (including their teammates) to achieve the game's objectives. Almost in every basketball team the tallest and strongest members are known as the center or power forward, while somewhat shorter and more agile players are known as small forwards, and the shortest players or those with the best ball handling abilities are known as point guards or shooting guards. The point guard is in charge of the team's on-court activity, executing the coach's game plan and overseeing the execution of offensive and defensive plays (player positioning). Basketball is, above all, a game about making decisions, which means that the players must be able to apply their skills in a constantly changing and highly varied environment. Basketball players move at a high rate in a small space.

Basketball is a game of skill. It is also a game of athletic ability and movement. Among all the games existing in the world, basketball is probably the leading ball game as far as fast movement is concerned. As a good player, not only one should has a good experience in the game and basketball skills, but also has the ability to move around quickly and be a better player. In the game of Basketball all the movements are involved like passing, throwing, changing the direction quickly, and sudden stop, jumping for rebound, feinting, manoeuvring the opponent while going for offensive move and guarding the opponents in the defensive. All these require rapid movements demanding frequent changes in direction. For one to respond to such a situation, a player should possess good motor fitness, physiological and psychological qualities. The game has many individual techniques for displaying skill like - ball-handling, shooting, passing, dribbling, dunking, shot-blocking, lay-ups and rebounding. The ability to shoot or score is a dominant factor of all these things. Basketball is primarily aimed at shooting the ball through the opposing basket. This is the only way to score points and only the team that can score higher than its opponents can achieve a success.

1.3 Factors of Success in Basketball

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. These qualities primarily involve the ability to work as a team and to cooperate with others, having best sport techniques, knowledge of the game etc. The players need to know very clearly how the game works and what should be necessary for that particular time. But the ability to operate under pressure is one of the most important characteristics. During a game, a lot of noise is always available and decisions must be made on site that are beneficial to the whole team. So, control over the mental condition is also an essential quality of every player.

There are other factors in basketball except these common factors. These are...

Positioning: Although the rules do not specify any positions whatsoever, they have become an integral component of basketball. There are some specific positions noticed in the basketball matches. But the current trend shows that many top coaches are going for the position less basketball, where the players are free to shoot from outside and dribble if their skill allows it. Popular descriptions of positions include:

Point guard (often called the "**1**") : Usually the team's fastest player, organises the offence by controlling the ball and ensuring that it reaches the appropriate player at the exact time.

Shooting guard (the "**2**") : On offence, he makes a lot of long-range shots, and on defense, he guards the opponent's best attacker player.

Small forward (the "**3**") : On offence, he is usually in charge of scoring points with cuts to the basket and dribble penetration; on defense, he looks for rebounds and steals. But he can also play more aggressively.

Power forward (the "**4**"): On offence, they frequently play with their backs to the basket and on defense, they commonly play beneath the basket (in a zone defense) or against the opposing power forward (in man-to-man defense).

Center (the "**5**"): Their height and size are used to score (on offence), defend the basket (on defence), and rebound.

The aforementioned descriptions are up to interpretation. The shooting guard and small forward on most teams have fairly similar responsibilities and are referred to as the wings, while the power forward and center are referred to as post players. While most teams narrate two players as guards, two players as forwards, and one player as a center, certain teams prefer to refer them by different names. (wikipedia)

Rebounding : The objective of rebounding is to successfully gain possession of the basketball after a missed field goal or free throw, as it rebounds from the hoop or backboard. This plays a major role in the game, as most possessions end when a team misses a shot. There are two categories of rebounds: offensive rebounds, in which the ball is recovered by the offensive side and does not change possession, and defensive rebounds, in which the defending team gains possession of the loose ball. The majority of rebounds are defensive, as the team on defense tends to be in better position to recover missed shots. (wikipedia)

Passing : A pass is a method of moving the ball between players. Most passes are accompanied by a step forward to increase power and are followed through with the hands to ensure accuracy.

A staple pass is the chest pass. The ball is passed directly from the passer's chest to the receiver's chest. A proper chest pass involves an outward snap of the thumbs to add velocity and leaves the defence little time to react.

Another type of pass is the bounce pass. Here, the passer bounces the ball crisply about two-thirds of the way from his own chest to the receiver. The ball strikes the court and bounces up toward the receiver. The bounce pass takes longer to complete than the chest pass, but it is also harder for the opposing team to intercept (kicking the ball deliberately is a violation). Thus, players often use the bounce pass in crowded moments, or to pass around a defender.

The overhead pass is used to pass the ball over a defender. The ball is released while over the passer's head.

The outlet pass occurs after a team gets a defensive rebound. The next pass after the rebound is the outlet pass.

The crucial aspect of any good pass is it being difficult to intercept. Good passers can pass the ball with great accuracy and they know exactly where each of their other teammates prefers to receive the ball. A special way of doing this is passing the ball without looking at the receiving teammate. This is called a no-look pass.

Another advanced style of passing is the behind-the-back pass, which, as the description implies, involves throwing the ball behind the passer's back to a teammate. Although some players can perform such a pass effectively, many coaches discourage no-look or behind-the-back passes, believing them to be difficult to control and more likely to result in turnovers or violations. (wikipedia)

Dribbling : Dribbling is the act of bouncing the ball continuously with one hand, and is a requirement for a player to take steps with the ball. To dribble, a player pushes the ball down towards the ground with the fingertips rather than patting it; this ensures greater control.

When dribbling past an opponent, the dribbler should dribble with the hand farthest from the opponent, making it more difficult for the defensive player to get to the ball. It is therefore important for a player to be able to dribble competently with both hands.

Good dribblers (or "ball handlers") tend to bounce the ball low to the ground, reducing the distance of travel of the ball from the floor to the hand, making it more difficult for the defender to "steal" the ball. Good ball handlers frequently dribble behind their backs, between their legs, and switch directions suddenly, making a less predictable dribbling pattern that is more difficult to defend against. This is called a crossover, which is the most effective way to move past defenders while dribbling.

A skilled player can dribble without watching the ball, using the dribbling motion or peripheral vision to keep track of the ball's location. By not having to focus on the ball, a player can look for teammates or scoring opportunities, as well as avoid the danger of having someone steal the ball away from him/her. (wikipedia)

Blocking : A block is performed when, after a shot is attempted, a defender succeeds in altering the shot by touching the ball. In almost all variants of play, it is illegal to touch the ball after it is in the downward path of its arc; this is known as goaltending. It is also illegal under NBA and Men's NCAA basketball to block a shot after it has touched the backboard, or when any part of the ball is directly above the rim. Under international rules it is illegal to block a shot that is in the downward path of its arc or one that has touched the backboard until the ball has hit the rim. After the ball hits the rim, it is again legal to touch it even though it is no longer considered as a block performed.

To block a shot, a player has to be able to reach a point higher than where the shot is released. Thus, height can be an advantage in blocking. Players who are taller and playing the power forward or center positions generally record more blocks than players who are shorter and playing the guard positions. However, with good timing and a sufficiently high vertical leap, even shorter players can be effective shot blockers. (wikipedia)

1.4 The Lay-up Shot

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.

A basketball layup is a two-point shot attempt that comes from below, places the ball up close to the basketball, and uses one hand to bounce it out of the backboard and into the basketball. The move and hand-held reach differentiate between a jump shot. “The most shot percentage in the game is in basketball. Many players can perform only one or two of the six variations correctly. The most commonly taught overhand lay-up is. The overhand lay-up is the easiest to learn in motion and is shot as if it were a regular shot” (Palazzo & Zimmerman, 2005).

The basketball layup is most often used when a player drives to the basketball and doesn't want to pass the ball and be able to ride around the defenders. Its precision is also a source of popularity. For the player, it is important to look at a few biomechanical directives to improve their layup and improve accuracy, increase the shot efficiency and accelerate the shot. This also tell us how our body can move effectively and how our skills can be improved.

A number of game situations may not warrant an inside shot of the backside, especially when an offensive player approaches the basket from the baseline or when an offensive player approaches the basket from the centre of the lane. None of these situations provide a good angle or view of the target point on the backside for the offensive player. Players should try to approach the basket using a good angle so that the target on the back board is fully seen and can be used as far as possible for the inside shot.

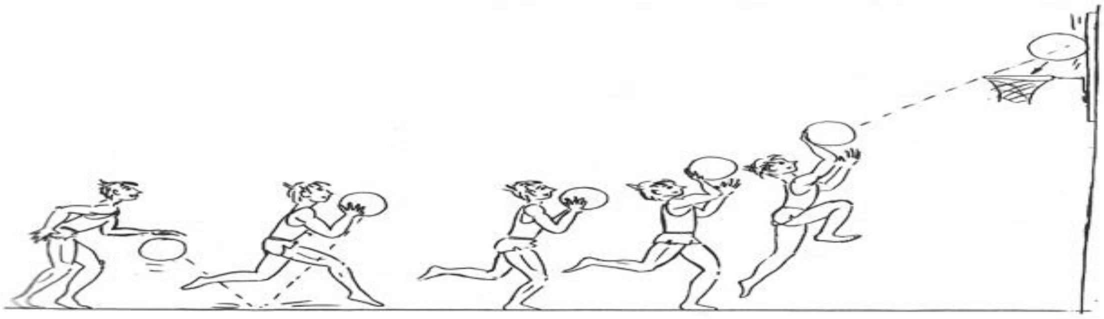
The layup has changed throughout time as the game has progressed. Today there are a number of different layup versions exists in basketball. The layups can be divided into two broad classes: the underarm and the overarm. Using the majority of the wrist and fingers, the underarm layup 'lays' the ball inside or outside the palm. The finger roll is more frequent in this lay-up. The other layup is the overhand shot from a very close range, similar to a jump shot. Excessive lay-ups involve almost always backboard action. This move has been used to great effect by the players in game situations. Another form is The Reverse Layup. It is a smarter way to close the ball.

The players often create a layup space by using the two steps allocated before the layup attempt. There are varieties and improvements, but the 'Euro-Step' is the most common form. As the NBA was introduced by European players, it was chiefly adopted by guards and forward as it relies heavily on agility and footwork to avoid bigger defenders. (wikipedia)

1.5 Biomechanics of Basketball Lay-up Shot

Biomechanics is concerned with two areas of study. The biological area; the biological aspects for movement and motion in the human body; and the mechanics; this utilizes Newtons laws and principals and applies them to human movement and motion (Wuest & Fisette, 2012). Biomechanists study how various forces affect human motion and how movements can be improved in terms of efficiency and effectiveness (Wuest & Fisette, 2012). (Knapman, 2014)

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). (Knapman, 2014)

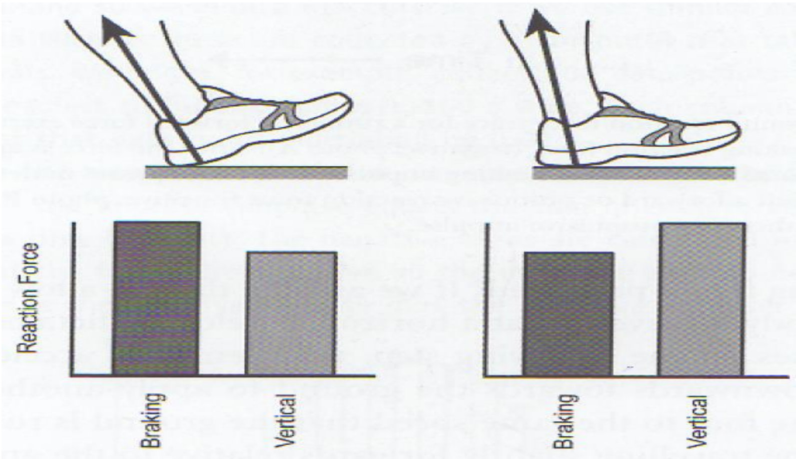


(Biomechanics of the Basketball Layup by Emily Knapman, 2014)

Biomechanics relating to the preparation phase of the layup (the run up).

Momentum

To change an objects momentum we have to apply a force, the larger the force, the greater the change in momentum. When a player hits the ground with their feet, they need to apply the largest force possible for the longest time possible. The greater the impulse, the greater the change in momentum; since our mass will change, our velocity should (Blazevich, 2010). (Knapman, 2014)



(Biomechanics of the Basketball Layup by Emily Knapman, 2014)

When a player's foot lands at a greater angle in front of the body the braking impulse is large. The total positive impulse is therefore smaller so acceleration is smaller. When a players foot lands at a smaller angle and further under the body, the braking impulse is smaller (Blazevich, 2010). The total positive impulse, however, is likely to be larger. So while players want to minimize the braking force, a small force plays a large role in the ability to run at high speeds (Blazevich, 2010). In sprinting, the braking impulse is usually greater when the foot lands further in front of the body; there is a trade-off where a small braking force is useful but a large force, generated when the foot lands well in front of the body's centre of mass, is detrimental (Blazevich, 2010). However, in basketball braking and sideways impulses are important for the players who need to slow down and change direction quickly. In the layup the dribble towards the basket needs to have some speed however, the two steps before the jump should be controlled and slower. From this information we can also say that when running and dribbling player's feet should not land on their heels, more like the middle. (Knapman, 2014)

Newton's First Law

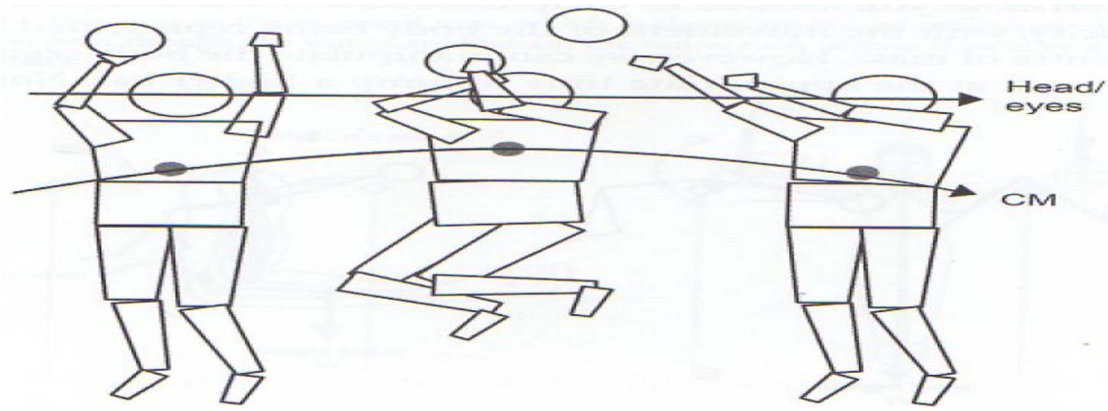
Newton's first law states that an object will remain at rest or continue to move with constant velocity as long as the net force equals zero (inertia) (Blazevich, 2010). All objects that have a mass have inertia, the larger the mass of an object the more difficult it is to change the objects state of motion (Blazevich, 2010). So if players want to jump higher, they need to work out how to change their state from rest or from a constant horizontal running velocity to vertical motion. In basketballs case this is when the player takes those two steps and uses their legs to throw their bodies into the air to reach the basket. (Knapman, 2014)

Newton's second law

Newton's second law states that the acceleration of an object is proportional to the net force acting on it and inversely proportional to the mass of the object (Blazevich, 2010). To change the state of motion of an object, we need to apply a force. The formula f=ma informs us that the lighter the object, the faster it will accelerate, or that less force will be needed to cause a given acceleration (Blazevich, 2010). The lighter a person is, the more they can accelerate their body under a given force. (Knapman, 2014)

This also applies when players are moving the ball up into the basket. They need to understand how much force to place on the ball to get it up and through the hoop. Players need to understand the balance between too much force (causing the ball to go out of control) and too little force (the ball doesn't get enough height). This knowledge of how much force to apply to the ball comes with practice. (Knapman, 2014)

What biomechanical aspects relate to the power production phase of the layup (the jump)?

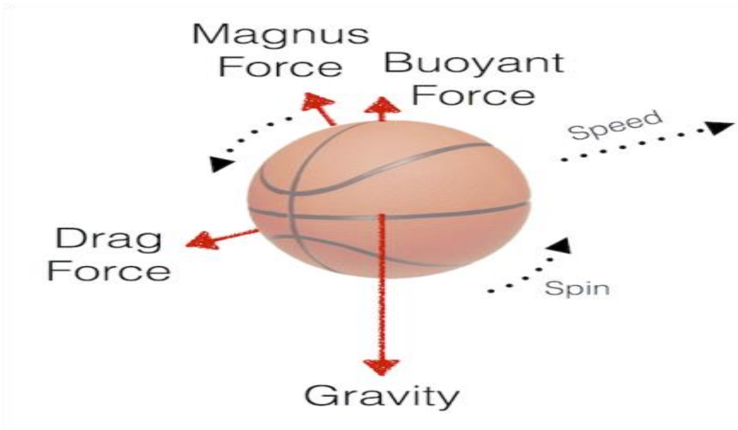


(Biomechanics of the Basketball Layup by Emily Knapman, 2014)

Centre of Mass

In evasive sports such as basketball, players try to move their centre of mass around an opponent, but to evade them they only need part of their body to be out of reach at any one point (Blazevich, 2010). In basketball, players might try to 'hang' in the air to block a shot or provide upper body stability to make a shot of their own. Players do this by bringing their legs up and under their body after they leave the ground during a jump (Blazevich, 2010). When someone would normally be about to fall back down towards the ground under the influence of gravity, players rapidly extend their legs downwards, to conserve momentum, their upper body moves upwards (Blazevich, 2010). In effect, since their body's centre of mass is moving downwards but, relative to it, their upper body is moving upwards, their upper body momentarily remains stationary or 'hangs'. Another important use of this centre of mass information is in helping players obtain balance during complex skills (Blazevich, 2010). This technique is useful when performing the jump in the layup; players want to have as much air time as possible. (Knapman, 2014)

When accelerating during running it is helpful for players to allow their centre of mass to move forward of their base support, this will cause a forward rotation of their body. This rotation, which is caused by the force of gravity, provides a forward acceleration that helps us move. By players implementing this rotation it helps with their movement efficiency. (Knapman, 2014)

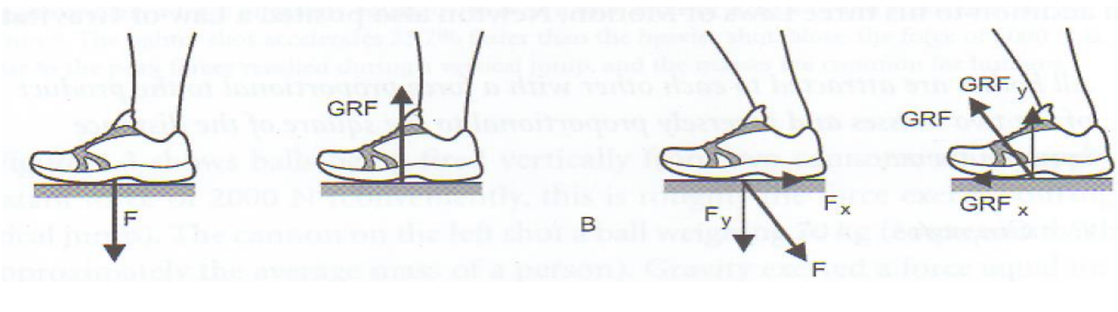


(Biomechanics of the Basketball Layup by Emily Knapman, 2014)

MagnusEffect

The most common explanation of the Magnus's effect is that the spinning ball 'grabs' the air that flows past it because of the friction between the air and the ball, so these air particles start to spin with the ball (Blazevich, 2010). According to the Magnus effect, if a player puts spin on the ball, where the top of the ball spins over the bottom of the ball (i.e. top spin), the air on top will slow down and the air underneath will move relatively quicker (Blazevich, 2010). Therefore, the pressure on top of the ball would be higher, a Magnus force would be directed down towards the ground and the ball would dip. This can help shooters to get the basketball to hit the back board and fall into the hoop. (Knapman, 2014)

Newtons Third Law



(Biomechanics of the Basketball Layup by Emily Knapman, 2014)

Newton's third law states that for every action, there is an equal and opposite reaction (Blazevich, 2010). When a player steps onto the ground a vertical downward forced is applied. The ground exerts an equal and opposite reaction force, this is called the ground reaction force (GRF), which stops player's feet from sinking into the earth. During running and jumping, players apply a force with both vertical and horizontal components (Blazevich, 2010). The ground exerts equal and opposite GRF, which can accelerate us forwards if the force is large enough to overcome our inertia (Blazevich, 2010). It is very important to produce large vertical forces, or have a lower body mass, to jump very high. For the layup this means players must use the power in their legs to propel them into the air, towards the hoop. (Knapman, 2014)

Jump– work, power, energy, and efficiency:

The amount of work when someone jump is equal to the average force that is applied multiplied by the distance over which it is applied. Several forces might act at any one time (Blazevich, 2010). The concept of work is important in sport in general, because we often need to manipulate it. The greater the total work done the better the performance will be (Blazevich, 2010). (Knapman, 2014)

At any time, the greater the force, or the faster the velocity, the power is greater. Power is increased when players do a given amount of work in less time or do more work in a given time (Blazevich, 2010). Increasing power results in an increase in the velocity of an object, as long as its mass remains constant. This principal also applies to people (Blazevich, 2010). (Knapman, 2014)

To jump up high, a basketballer has to perform a greater amount of work, or attain higher power but they also need to repeat such jumps numerous times in a game (Blazevich, 2010). If players jump in the air they increase their potential energy. This also means that players need to have a lot of energy to repeatedly perform jumps and movements throughout the game. (Knapman, 2014)

Efficiency is the ratio of energy output to input (Blazevich, 2010). To improve a players jumping efficiency, not just their jump height, they need to increase the output (kinetic energy, resulting in greater jump height) while decreasing the input (the energy required to jump) (Blazevich, 2010). The power that players use to jump comes from muscle contraction. (Knapman, 2014)

Follow through and recovery phase aspects

The kinetic chain

One of the kinetic chain pattern categories is the push-like movement pattern. A push-like movement pattern is when a person moves as if they are pushing something. Players tend to extend all the joints in their kinetic chain simultaneously in one single movement (Blazevich, 2010). The benefits of using a push-like movement pattern are that the joins are acting simultaneously the cumulative forces (torques) generated about each joint result in a high overall force, it is efficient, highly accurate, and results in a straight-line movement at the end point of the chain (Blazevich, 2010). However, a drawback of the push-like movement is slow movement speed (Blazevich, 2010). However, in the layup this slow movement speed can be helpful to players; it allows them more control over the ball. The throw-like movement pattern produces higher speeds but this isn't an attribute required for the layup, the ball does not have to travel at high speeds when performing the shot. (Knapman, 2014)

A flick of the wrist directs the ball into hoop. Once the ball is released from the players hand the fingers must follow in a flick like motion with the wrist. This helps direct the ball into the hoop and ends the kinetic chain completely. (Knapman, 2014)

Landing – landing with soft knees. As with any landing it is important for players to land with soft knees

(Biomechanics of the Basketball Layup by Emily Knapman, 2014)

1.6 Background of the Study

The basketball game began in India in 1930 when the game first took place. In 1934, New Delhi held the first Indian National Men's Championship. In 1950 was established the Indian Basketball Federation (BFI), which controls games in India. Throughout history Indians have learned to appreciate this game from start to finish because of its fast score and intense activity. It is now considered to be one of India's most common sports. India is one of the first countries in the history of basketball to adopt the game in a few years' time. (wikipedia)

The majority of schools, colleges and universities are involved in Basketball. Basketball in India. The younger generation has considerable support for the game. The men and women of all ages and abilities play basketball in India. Many government agencies have professional basketball teams that work for and play for the institution. Their respective institutions and states are the ONGC in Uttarakhand, Tamil Nadu Indian Overaseas Bank, Karnataka Indian Bank, Mahanagar Telephone Nigam Limited, New Delhi Indian Railways and the Kerala Electricity Board. (wikipedia)

There are many championships for senior, junior, and youth levels for boys and girls. Invitational all-India tournaments like Master Prithvinath Memorial (New Delhi), Don Bosco Invitational Tournament (Mumbai), Ramu Memorial (Mumbai), and many other tournaments in the southern part of India are being organized every year. Unlike many other countries like America, Russia, China, and Japan, basketball in India does not follow seasons. Indian basketball has championships throughout the year for different age groups. Championship for youth are mainly organized between April to July when children are having summer break from school. (wikipedia)

Being one of the earliest countries to adopt basketball, India has so far produced numerous talented basketball players, who have earned recognition in the international arena. Indian basketball players have also won several trophies for their country. Basketball in India is mainly being run and managed by a large number of national and state level associations, spread all over India. These basketball associations are working with a common view of popularizing the game in all parts of the country. Apart from that, developing the overall infrastructure for the game and uncovering new talent from the grass route level are some of the other principal objectives of the Indian basketball associations. (wikipedia)

NBA in India

The National Basketball Association has realized the immense potential of the sport in this large and growing market, and is working hard with the Basketball Federation of India to expand the popularity of the sport.

Late in 2008, NBA great, Robert Parish, came to India as part of the NBA/WNBA Hoop School Program. This relationship further expanded into a cultural exchange, which saw Bollywood superstars Lara Dutta and Dino Morea make a trip to watch the Los Angeles Lakers in action, and on April 8, 2009, saw the NBA inaugurate a refurbished basketball court in a suburb in Mumbai.

In April 2015, Sim Bhullar (born December 2, 1992), a Canadian of Indian descent, made his professional debut in the NBA. He became the first player of Indian descent to play in the

NBA. Two months later, Satnam Singh Bhamara became the first Indian to ever be selected in the NBA by being the 52nd pick in the 2015 NBA draft for the Dallas Mavericks. He'd also be the first player to be drafted as a high school postgraduate.

In April 2017, India on track (IOT) collaborated with NBA to form NBA Basketball Schools to train kids and teach them to play the NBA way. There are more than 12 centers running around the country from Delhi, Mumbai, Pune, and many more. (wikipedia)

IMG Reliance joint venture

In June 2010, a deal was struck with the BFI and the IMG Reliance joint venture which aims to take Indian basketball to a professional level. The 30 year deal sees IMG Reliance take control of the game launching a league, controlling merchandise, developing infrastructure and other commercial aspects in this new development. The BFI will launch and control school and college leagues with assistance from the IMG. IMG Reliance will also construct academies in India in line with the IMG Florida sports academy. In July, coaches from Florida came to India to select 8 boys and girls between the ages of 13-15 to take to the US on a scholarship. The first batch was selected and is preparing to undertake the scholarship at IMG Florida. More scholarships will be offered with the aim of launching India's first professional league in 4 years. IMG chief Ted Fortsmann and Reliance owner Mukesh Ambani see the IPL as a perfect model to use. Therefore, a franchise system is likely to be put into place. (wikipedia)

At the moment the NBA are not involved with the joint venture but Ted Fortsmann is willing to work with the NBA who already run recreational leagues in India with another leading Indian business, the Mahindra Group. These are set in expand from the initial 3 cities to other parts of India. (wikipedia)

One of the first people to have been accepted to the IMG Reliance program, Satnam Singh Bhamara, had also declared to go for the 2015 NBA Draft while coming straight out of the IMG Reliance program as a post-graduate. When Bhamara was selected by the Dallas Mavericks as the 52nd pick of the draft, he would be the first player to have been drafted directly out of high school without any additional international, college, or D-League competition since Amir Johnson back in 2005. (wikipedia)

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. This is true, for example, for the shot-put technique applied first by O'Brien. An essentially better path of acceleration of the shot can be implemented by this technique. Looking at the obvious progress in the development of technique in sports and investigating it more in detail from biomechanical points of view, we generally find starting points for objective criteria in an analysis of the efficiency of motor dynamics. We thus found some starting points for the Biomechanical principle of the optimal path.

1.7 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".**

1.8 Objectives of the study:

The objectives of the study are –

- 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.

1.9 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.

1.10 Limitations of the Study

The present study was conducted under following limiting conditions:

1. The previous fitness level of the players was not 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.

1.11 Definition and Explanation of Terms

The following terms were defined and explained to provide consistency in terminology:

i. **Biomechanics:** Study area where the knowledge and the method of the mechanism are applied to the structure and function of the living human system.

ii. **Layup shot:** A layup in basketball is a two-point shot attempt made by leaping from below, laying the ball up near the basket, and using one hand to bounce it off the backboard and into the basket. (Wikipedia)

iii. **Basketball:** Basketball is a team sport in which two teams of five players try to score points by throwing or "shooting" a ball through the top of a basketball hoop while following a set of rules. Basketball is one of the world's most popular and widely viewed sports (Griffiths, 2010).

iv. **Kinematics:** It is that branch of Biomechanics i.e. concerned with describing the motion of body. Thus, Kinematics deals with such things as how far a body moves, and how consistently it moves. It is not concerned at all with what causes a body to move in the way it does. Kinematics analysis motion in terms of time, displacement, velocity or acceleration.

v. **Anthropometry:** Anthropometry is the science of measuring the human body and its parts. It is used as an aid to the study of human evaluation and variations (Clarke and Clarke, 1976).

vi. **Center of gravity:** The center of gravity of any object is that point at which all of the weight of an object may be concentrated. The center of gravity is referred as the point of balance of a body and it is either stated or implied that it is possible for it to be balanced or supported.

vii. **Age:** Age is the amount of time something has been alive or has existed in the world.

viii. **Height:** Height is the vertical measurement from the heel to top of the head of the human body (Sutcliffe and Ganham, 1981).

ix. **Weight:** Body weight is described as the mass of an organism's body and it was measured in kilograms (Sutcliffe and Ganham, 1981).

x. **Arm length:** It is the distance from glenoid fossa of shoulder joint to the tip of the middle finger (Johnson and Nelson, 1982).

xi. **Leg Length:** Leg length is defined as the distance between greater trochanter to the floor (Johnson and Nelson, 1982).

xii. **Two hand distance:** It is the (sometimes referred to as wingspan, or spelled "arm span") physical measurement of the length from one end of an individual's arms (measured at the fingertips) to the other when raised parallel to the ground at shoulder height at a 90° angle. (Wikipedia)

xiii. **Two and half step length:** As the players approach to the hoop, first they take a half step with their outside foot, then take a full stride with their inside foot pushing off the court. When they are jumping, with their head up and eyes focused on the backboard and just releases the ball from their hand in that particular moment the distance between the first stride and this particular point is their two and half step length.

xiv. **Approach speed:** The approach is a gradual acceleration that is neither a sprint nor a jog, but rather a had controlled stride. In basketball layup shot, approach Speed is the speed at which an athlete runs while he is on the final stage to going for the layup.

xv. **Take off velocity:** Take off velocity is the speed of an athlete in a specific direction and is the rate of change of displacement, at the phase of flight in which a player leaves the ground and becomes airborne.

xvi. **Take off Angle:** This is defined as the angle of Cg with the horizontal at take off.

xvii. **Horizontal Velocity at Take off:** Velocity is the rate of displacement. In the present study the horizontal velocity of Cg. at take of during the execution of the selected skills was considered.

xviii. **Vertical Velocity at Take off:** Like horizontal velocity of Cg. at take of during the execution of the selected skills the vertical velocity of Cg. was also considered in the present study.

xix. **Height of ball release:** The height of ball release is the vertical distance between the basketball and the floor of basketball court/ground at the time of release.

xx. **Angle of ball release:** Angle of release is the angle at which the ball is released relative to horizontal plane. (http://www.coachr.org/critical factors in the shot put.html). The angle, relative to the ground, at which a body is projected into the air. The angle of release is an important factor affecting the flight path of a projectile.

xxi. **Speed of ball release:** Speed of release or projectile speed is the speed of a projectile at the instant of release (Bartlett, 2007). Release speed is defined as the maximum speed at which a thrower is throwing the ball.

xxii. **Segmental joint angular velocity (At release):** Angular velocity is defined as the rate of change of angular displacement, θ, with respect to time, t, and for an object rotating about a fixed axis at a constant speed (Newnes Engineering and Physical Science Pocket Book, 1993). In physics, angular velocity refers to how fast an object rotates or revolves relative to another point, i.e. how fast the angular position or orientation of an object changes with time. There are two types of angular velocity: orbital angular velocity and spin angular velocity.

xxiii. **Ankle angle:** Defined as by anatomical lines between the tibia and foot at ankle joint.

xxiv. **Knee angle:** Defined as by anatomical lines of femur and tibia.

xxv. **Shoulder angle:** Defined as by anatomical line of hummers and line draw between hip joint to shoulder joint.

xxvi. **Elbow angle:** Defined as by anatomical line of radius and line draw between shoulder joint to elbow joint.

xxvii. **Wrist angle:** Defined as by anatomical lines of radius and line draw between of the longest finger to wrist joint.

xxviii. **Duration of total flight:** This was the time for which a player remains in the air during the execution of the skills.

1.12 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 zones of the two point field goal area for both male and female basketball players.

1.13 Significance of the study:

The results of the study would help the field of physical education and sports in many ways. Some major influence would be as follows:

- ✓ The result of the study would be helpful to thoroughly understand the biomechanical factors behind the selected technique.
- ✓ The errors committed by the players during the layup shot in basketball would be pointed out.

- ✓ The result of the study will provide the suggestions which could be helpful for rectifying the errors committed by the players during the layup shot in basketball.
- ✓ The difference between the male and female layup technique in respect to the selected biomechanical factors would be clearly understood.
- ✓ The result will help the low level players needed to raise their performance level by giving them specific information about the particular skill.
- ✓ The result would have a great significance for specific training of basketball players.
- ✓ The result of the study may be helpful to teach the lay-up shot more scientifically.
- ✓ The result may be helpful for the prevention of injury of the basketball players.
- ✓ The result will also be helpful for future study and research.
- ✓ The study will enrich the area of Physical Education and Sports.

CHAPTER 2

REVIEW OF RELATED LITERATURE

Chapter - II

REVIEW OF RELATED LITERATURE

The evaluation of related literature serves as a reference for identifying general trends in previous research efforts in the field or area under question. Some of the review of literature that the researcher discovers could be very helpful and strengthen the study. Following a review of the existing literature, the investigator shared some of the experts' observations and findings. The evaluation also aids the investigators in defining the problem and offering direction for the research they are conducting.

A survey of related literature, allows the researcher to have a better grasp of past work. It would deepen the researcher's understanding. A review allows us to have a better understanding of the methodology, measures, subjects, and apparatus used by other researchers. Any researcher can use the literature to find out what is already known about a topic. The literature on any subject aids the researcher in discovering what is already known, allowing the researcher to gain a deeper comprehension, a clearer perspective, and a better understanding of the chosen problem and its different elements. On the following pages, an attempt has been made to present briefly a few of the most important research and studies were undertaken both abroad and in India, as they are relevant to the current topic.

The reviews of the literature have been classified under the following headings…

2.1 Reviews on Biomechanics.
2.2 Reviews on Basketball.
2.3 Reviews on Lay-up shot.
2.4 Reviews on Parameters Related to this Study.

2.1 Reviews on Biomechanics

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±7.22cm), weight (168.07±6.68kg). 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.

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.

Huang Chi (2009) analysed the, "**Biomechanical Analysis of Standing Long Jump"** with handheld weight. The purpose of this study was to investigate the biomechanical difference between unloaded and loaded groups, and to understand the joint moment and power of standing long jump. Fourteen male physical education students (height 174.64±6.21 cm, weight 73.07 ± 11.32 kg) participated the study, and performed no load, light load (L load, load 2-4kg), heavy load (H load, load 6-8kg）, super heavy load (S load, loag10-12kg) standing long jumps. A Redlake high speed camera (125Hz) was synchronized with a Kistler force platform (1250Hz) to collect the data, and Dempester's study (1955) was used to calculate the human body parameter. We use one way ANOVA to analyse the kinematic data, and the variables were calculated by SPSS for Windows (Version 12.0, Chicago, IL) with alpha level of 0.05. It was analyzed that the jumping distance was enhanced in the L loaded and H loaded groups, the result was familiar to other studies, and if the jumper jumped carrying too heavy weight, the performance was decreased. Besides, the horizontal CM takeoff velocity in L load and H load groups increased with load. In vertical CM takeoff velocity, it decreased with load, especially when they jumped with super heavy load (10kg-12kg). In our study, there was no significant difference between groups in joints moment. In the peak joints power, it decreased with load, and the S load group significantly less than the other three groups. The study indicated that the light load and heavy load groups had greater jump distance than no load group. The horizontal body CG takeoff velocity and horizontal impulse were enhanced with load. However, the vertical body CG takeoff velocity, peak hip and ankle joint angular velocity, and peak lower extremity joints power were decreased with load.

A.S. Sajwan (2008) examined the, **"Biomechanical Analysis of Block Start in 100 Meters Sprint"**. The analysis was conducted on four sprinters two boys and two girls of L.N.I.P.E Gwalior. The analysis of block start was made on the basis of video-recording by sony handy cam DCR-HC96. The movement was executed in plane which was perpendicular to the video camera's field view. In the beginning of video recording to record an object of known dimension (scale), the scale usually one black rural was placed in the plane of the action-precisely 1 meter. Biokin 2D motion analysis system V4.5 was used to analyze the block start of the selected subjects. Results showed that the trajectory, displacement linear velocity, linear acceleration of knee and ankle joint of the sprinter, one boy and one girl was in better position in quantitative evaluation. The results were visualized using graphs, stick figure and videos simultaneously on screen to measure the distance or angle. It was further concluded that the length of acceleration was determined by the starting position of the knee and when the body is stretched. It was concluded that one boy and one girl's set positions was correct that had helped them to achieve lower trajectory, better displacement and good velocity of the knee and ankle joint.

Vanezis and Lees (2005) researched on the, **"Biomechanical Analysis of Good and Poor Performers of the Vertical Jump**." The aim of this research was to investigate the contribution made by the lower limb joints to vertical jump performance by good and poor performers of the counter-movement jump. Two groups of players were selected who were found to be the good and poor jumpers, respectively. Each player was required to perform three maximal vertical counter-movement jumps with, and three jumps without an arm swing. The jump performance was recorded simultaneously by means of a force platform and a Pro Reflex automatic motion analysis system at 240 Hz. Values at the ankle, knee and the hip were computed from these data for the joint moments and power. Generally, better jumpers demonstrated greater joint moments, power and work done at the ankle, knee and hip and as a result jumped higher under both conditions. It appears that the superior performance of the better jumpers was due to the greater muscle capability in terms of strength and rate of strength development in the all lower limb joints rather than to technique, which differed less noticeably between the groups. It was concluded that the muscle strength characteristics of the lower limb joints are main determinant of vertical jump performance with technique playing a smaller role.

A. Lees (2002) reviewed the, "**Technique Analysis in Sports**." In this paper the researcher critically reviewed the technique analysis as an analytical method used within sports biomechanics as a part of performance analysis. The concept of technique as 'a specific sequence of movements' appears to be well established in the literature, but the concept of technique analysis is less well developed. Although several descriptive and analytical goals for technique analysis can be identified, the main justification given for its use is to aid in the improvement of performance. However, the conceptual framework underpinning this process is poorly developed with a lack of distinction between technique and performance. The methods of technique analysis have been divided into qualitative, quantitative and predictive components. Qualitative technique analysis is characterized by observation and subjective judgement. Several aids to observation are identified, including phase analysis, temporal analysis and critical feature analysis. Although biomechanical principles of movement can be used to form judgements about technique, little agreement exists about the number and categories of these principles. A 'deterministic' model can be used to identify factors that affect performance but, in doing so, technique variables are frequently overlooked. Quantitative technique analysis relies on biomechanical data collection methods. The identification of key technique variables that affect performance is a major issue, but these are poorly distinguished from other variables that affect performance. Quantitative analysis is not suitable for establishing the characteristics of the whole skill, but new methods, such as the use of artificial neural networks, are described that may be able to overcome this limitation. Other methods based on modelling and computer simulation also have potential for focusing on the whole skill. Predictive technique analysis encompasses these developments and offers an attractive interface between the scientist and coach through visual animation methods. He conclude that biomechanists need to clarify the underpinning rationale, framework and scope for the various approaches to technique analysis.

Yoshinori, Tadao and Shingo (2001) have studied on the, **"Biomechanical Study of Human Jumping with Different Take-off Angles and Jump Heights."** In this research, they investigated the way in which human control the take-off angles and the strength in counter movement jumps, using a high-speed video camera, a force platform and EMG recordings. five university male athletes were selected as the subjects. The joint works and time integrals of EMG of lower limbs were calculated. Close negative correlations were seen between take-off angles and the hip joint work and between the take-off angles and the IEMG of the biceps femoris. This suggests that the forward propulsion needs the hip joint work and activity of the biceps femoris. Close positive correlations were seen between the jump heights and the contribution of the hip joint work to the total work and between the jump heights and the IEMG of the gluteus maximus. This suggests that the upward propulsion needs the hip joint work and the activity of the gluteus maximus.

H. Yuexin (1999) has studied on **"Biomechanical Analysis and Technical Characteristics of Approach Run in Arc in Fosbury -flop."** At present the speed in the approach run of Fosbury flop is increasing rapidly day by day. When the body is approaching in the arc, it attains a realistic and suitable inward obliquity. Thereby, the lift angle is increased, the approaching speed is accelerated and a good result of take-off is obtained, so as to achieve more perfect results of high jump. By applying biomechanical theory, the correlative factors of the inward obliquity of the body during approaching in the arc, the characteristics of that movement, the speed of the approach and the radius of the arc were analyzed and discussed. The internal relations of those correlative factors were found out in order to keep away from unilateral pursuing inward obliquity and acceleration, which is of great importance in practice.

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

2.2 Reviews on Basketball

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.

Weihsun Tai et al., (2019) examined the, **"Biomechanical Characteristics of Single Leg Jump in Collegiate Basketball Players Based on Approach Technique."** The study investigated the characteristics of the biomechanics of lower extremities during running single leg jump (RSJ) in collegiate basketball players. Twelve division III male basketball players voluntarily participated in this study. They performed three trials of the running single leg jump with two approach speeds (fast and preferred) randomly. The kinematic data were collected by motion analysis system (200 Hz), and kinetic data were collected using the AMTI force platform (1000 Hz), and electromyography (EMG) data were recorded by the Delsys surface Electromyography (EMG) system (2000 Hz). Kinematic, kinetic and EMG signal were synchronized using EvaRT 4.6. Peak Ground reaction force, eccentric loading rate (ELR), gastrocnemius (GA) of pre-activation phase, and tibialis anterior (TA) of push-off phase were found significantly larger in the fast approach speed ($p < 0.05$). RSJ improves muscle activation level and stretch reflex. Higher activation of TA and GA during RSJ may have the benefit of decreasing risk of injury and jump training. Thus, it is helpful in muscle stretch adaptation.

Inaba, Hakamada and Murata (2017) analysed the, **"Influence of Selection of Release Angle and Speed on Success Rates of Jump Shots in Basketball."** The purpose of this study was to investigate the influences of the selection of release angle, release speed and spin rate, and variability on the success rate of jump-shots in basketball. Ten male collegiate basketball players participated in the study and actual ball trajectories for the jump-shots from the free-throw (FT) and three-point (3P) lines were recorded by the three-dimensional motion analysis system. The experimental data was compared with the theoretical optimal release parameters. We found that the players with higher success rate in FT shots had a higher release position, a lower release velocity, and a larger margin for error for the release speed. On the other hand, for the 3P shots, the player with a larger margin for error for the combination of the release speed and angle had higher success rate. Variability in release parameters did not have significant correlation with the success rate.

A. Changjan and W. Mueanploy, (2015) researched the, **"Projectile Motion in Real-life Situation: Kinematics of Basketball Shooting."** In this study they consider the case when the ball is released from the player's hand. The relationship between the optimal angle, the minimum initial velocity and the height of the ball before the player shoots the ball for basketball shooting problem are calculated analytically. The effect of air resistance to movement of the ball and the force due to the spinning motion of the ball will be considered negligible. They find that the value of optimal angle and the value of minimum initial velocity decreases with increasing the height of the ball before the player shoot the ball. They explained that they can use this result as an example to describe the projectile motion that the beginning level is different from final level.

Artur Struzik, Bogdan Pietraszewski, Jerzy Zawadzki (2014) studied the, "**Biomechanical Analysis of the Jump Shot in Basketball**." The jump shot is considered to be the most important element of technique in basketball and requires a high level of performance. The aim of this study was to compare the biomechanical characteristics of the lower limbs during a jump shot without the ball and a countermovement jump without an arm swing. The differences between variables provide information about the potential that an athlete can utilise during a game when performing a jump shot. The study was conducted among 20 second-league basketball players by means of a Kistler force plate and the BTS SMART system for motion analysis. The variables measured included the take-off time, mean power, peak power, relative mean power, jump height, maximum landing force and calculated impact ratio. Surprisingly, more advantageous variables were found for the jump shot. This finding suggests a very high performance level in the jump shot in the studied group and a maximum utilisation of their motor abilities. Both types of jumps were characterised by high mean and peak power values and average heights. The high forces at landing, which result in considerable impact ratios, may have prompted the studied group to land softly.

P. Ranjith and Dr. P. Rajini Kumar, (2014) examined the, **"Biomechanical Analysis of Set shot in Basketball."** The aim of this study was to analyse the selected biomechanical factors of set shot in basketball. Men (n=21) Basketball players represented university were purposively selected from Tamil Nadu state, India for this study, the age of the subjects ranged from 18 to 28 years. The subjects had past playing experience of at least four years in basketball. Written informed consent was obtained from players. The high definition camera (Sony 10) was used to record the performances that were approximately transverse to the trajectory of the plane of motion. Video footage was digitized using Kinovea software for data analysis of speed of release, relative height, angle of release, apex of the ball and accuracy. The collected data was statistically analysed by using descriptive statistics and pearson's correlation coefficients. The finding reveals that the accuracy has significant relationship with speed of release, relative height and angle of release. Among the selected variables accuracy and speed of release having highest relationship.

Birendra Jhajharia, Upendra Pandey and Mandeep Singh, (2012) investigated the, **"Kinematical Analysis of Female Basketball Players in 3 Point Shot."** For this study, ten female basketball players of CSJM University, Kanpur, were selected as subjected for the study. The videos as obtained by the use of digital videography were analyzed (the best trial) by Siliconcoach pro 7 software. Only one selected frame was analyzed. Selected variables were as 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 have 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 and incase of Ankle joint and Shoulder joint (right) showed significant relationship with the performance of subjects of coefficient of correlation for 8 degree of freedom is 0.632.

Riadh Khlifa, Ridha Aouadi, Souhail Hermassi, Mohamed Souhaiel Chelly, Chedly Jlid and Tim J. Gabbett, (2012) have analysed the **"Kinematic Adjustments in the Basketball Free Throw Performed with a Reduced Hoop Diameter Rim."** The aim of this study was to investigate the effect of free throw shooting with a reduced diameter rim (diameter 0.35 m) upon the kinematics of basketball free throws. Ten basketball players (mean ± SD age 17.1 ± 0.7 years, height 1.85 ± 0.23 m, body mass 78.8 ± 5.8 kg) performed 8 "clean" successful free throws; 4 in a standard rim (diameter = 0.45 m), and 4 in a reduced diameter rim (diameter = 0.35 m). Ball release angle, ball release speed, ball release height and angles at release in elbow, shoulder, trunk, knee and ankle joints were determined for each subject. Statistical analysis showed significant increases in ball release angle, in ball release speed, in shoulder joint angle at release ($p < 0.0001$) and in ball release height ($p < 0.01$) when shooting in a reduced diameter rim. There were no other significant differences ($p > 0.05$) in any other determined parameter between the standard and reduced rim conditions. Result showed that the increase of the minimum entry angle of the ball through the rim, caused by the 0.10 m reduction in diameter of the standard rim, resulted in subjects performing clean successful free throws with higher release angles and consequently with higher release speeds.

S. T. Jakovljevic, M. S. Karalejic, Z. B. Pajic, M. M. Macura & F. F. Erculj (2011) identified and compared the speed and agility of 12- and 14-year-old elite male Basketball players, and to investigate that they conducted a study entitled, **"Speed and Agility of 12 and 14 Years Old Elite Male Basketball Players"**. Sixty-four players aged 12 (M=11.98, SD=.311) and 54 players aged 14 (M=14.092, SD=.275) were tested. Three agility tests: agilityT-test, zigzag agility drill and agility run 4×15 m and three speed tests: 20-m run, 30-m run, and 50-mrun were applied. Fourteen year-old players achieved significantly better results in all speed and agility tests compared to 12-year-old players. The correlation coefficient (r=0.81, p=.001) showed that 12-year-old players have the same ability in 30- and 50-m runs. The other correlation coefficient (r=0.59, p=.001) indicated that 20-m and 30-m runs had inherently different qualities. The correlation coefficients between agility tests were lower than 0.71 and therefore each test in this group represents a specific task. In 14-year-old players, the correlation coefficients between the speed test results were lower than 0.71. In contrast, the correlation coefficients between the agility tests were higher than 0.71, which means that all three tests represent the same quality. During the speed training of 12-year-old players, it is advisable to focus on shorter running distances, up to 30m. During the agility training of the same players, it is useful to apply exercises with various complexities. In speed training of the 14-year-old players, the 30- and 50-m runs should be applied, and agility training should include more specific Basketball movements and activities.

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

Walsh, et al., (2007) investigated the, **"Gender Bias in Jumping Kinetics in National Collegiate Athletic Association Division I Basketball Players."** They examined gender differences in the contribution of the arm swing to jump height in men and women Basketball players and to examine the role of upper-body strength in the contribution of arm swing to jump height. National Collegiate Athletic Association Division I Basketball players (men n = 13, women n = 12) performed 4 jumping movements: squat jumps with hands on hips (SNA) and with arm swings (SA) and countermovement jumps with hands on hips and with arm swings (CMA). These results showed that the arm swing contributes significantly to jump performance in both men and women Basketball players and that strength training for jumping should focus on power production and lifting exercises that are jump specific.

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

Sallet, et al., (2005) conducted a study on **"Physiological Differences in Professional Basketball Players as a Function of Playing Position and Level of Play."** They evaluated the physical and physiological characteristics of different first (ProA) and second division (ProB) professional Basketball players, and related them to playing position and level of the play. A total of 58 players were divided into ProA and ProB groups and were assessed for physical characteristics, maximal treadmill test and a 30 s all-out test. The sample included 22 centers, 22 forwards and 14 guards. In conclusion, many physical differences, most notably size, exist between players as a function of their playing position. But these differences have no relationship to the level of the play of professional players. General aerobic capacity is fairly homogeneous between playing position and level of play, even if there are observable VO2max differences due to inter-individual profiles.

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

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

2.3 Reviews on Lay-up shot

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.

Khan Nazia (2015) conducted a study entitled, **"Relationship of Selected Kinematical Variables with the Performance of Female Basketball Players in Lay- Up Shot"**. The purpose of this study was to measure the relationship of selected kinematical variable to the performance in lay-up shot. The study was delimited to female basketball players of C.S.J.M. University, Kanpur. The study was further delimited to the10 subject belonging to the age group 17 to 28 years. The subjects were only right handed shooters. The scores of the subjects in Lay-up shot were used as the criterion variable in the study. The performances of the subjects were assessed by three judges however elements related to the accuracy of shooting were also added. Used in three point scale. Three point awarded in correct action and basket scored. Two points awarded in correct action but not scored. One point awarded in touches the ring or board. Siliconcoach pro 7 software was used for kinematical analysis of Lay-up shot in basketball. A Casio Exilim F-1 High Speed Camera, which was positioned at 7.90m from the subject at an height of 1.50m. from the subject on an extension of free throw line. Camera was also set for capturing 300 fps. The subjects were made to take three Shots only. The angular kinematical variables of the body were calculated at moment execution. The videos as obtained by the use of digital videography were analyzed (the best trial) by silicon coach pro 7 software. Only one selected frame was analyzed. Selected variables were as under. Were represented by the angles at selected joints as Ankle joint, Knee joint, Hip joint, Shoulder joint, elbow joint, Wrist joint and Body inclination. Other variables were height of release, last stride, arm span and Standing Height of Player. In case of Ankle joint (right), shoulder joint (right), Elbow joint (right) Wrist joint (right) and Hip joint (right) showed insignificant, but Elbow joint are very closed to the significant and incase of knee joint (right), showed significant relationship with the performance of subjects in Lay- up shot.

J. S. Hanna (2014) conducted a study entitled, **"Comparison of Some Kinematic Variables of Layup Basketball of Older and Young Players"**. Basketball is a game that requires being fast in both attack and defense with a precision in tactical and technical preparation. The layup technique can effect on the score dramatically and provide teams winning of the game. However, strength, speed and accuracy are the basic requirements interact with technical for an effective layup, and the kinematic analysis is a type of biomechanics analysis that care of descript the movement. Therefore, the objective of this study was to investigation biomechanical parameters of layup which can effect on the score and to find out the difference between the layup techniques of players experienced and younger group player of the same university team. A descriptive research design used in the current study. The population of this study was undergraduate male basketball players of the University of Mosul -Iraq, for the academic year 2012-2013, each sample included (6) male basketball players; young players=(176.7 cm tall), (18,3 years age) older player =(179.6 cm tall), (23,3 years age). The procedure of this research started with warm up for 15 minutes followed by passing, shooting, and the players performed the layup technique by repeated 3 times and the best performance of layup was selected to analyze. Data were analyzed using SPSS version 19.0, Mean variables compared by T-test at 0.05. Programs of Maxtra and Dartfish used for analysis. This study conclude that -The length and speed of first and second step for older players higher for the older player than the youth, The older players were better in all tested variables (horizontal and vertical distance, Hips Displacement for jumping, Height of palm, distance of take-off from basketball).

Nathial Mandeep Singh (2014) conducted a study entitled, **"Analysis of Set Shot in Basketball in Relation with Time to Perform the Course and Displacement of Center of Gravity."** The purpose of the study was to analysis of the technique of set shot while attempting free throws with the performance, in relation with time to perform the course and displacement of center of gravity. Sixty National level male basketball players of three different height groups were selected as the subjects. The data was obtained from two given positions (i) Moment of stance in set shot and (ii) Moment of release of ball in set shot. Total ten attempts were given and the successful shots marked as score out of ten as criterion measure of performance. It was found that there is significant relationship between the time to perform the course and the performance in set shot of different height group players in basketball and there is no significant relationship found between the displacement of center of gravity and the performance of set shot of different height group players in basketball and therefore, the selected variable puts no impact on the performance of set shot. Further it was concluded that displacement of center of gravity was significantly different in first group from the other two groups.

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.

S. K. Yadav (2011) conducted a study entitled as, **“Construction of an Objective Skill Test for Lay-up Shot in Basketball”**. The purpose of this study was to construct an objective skill test for lay-up shot test in basketball. The experiment was initially conducted as a pilot study on 15 inter collegiate male basketball players on three different variations of lay up shot namely: Dribble and lay up shot, Underhand lay up shot and lay up shot with passive defense. Reliability of all the three tests was computed and the first test was statistically significant, whereas the other two were insignificant. Hence, the Dribble and Lay up shot test were selected for further study. Fifty male basketball players who participated in Inter-collegiate/District level basketball tournament were selected to serve as a subject for this study. The age of subjects ranged between 18 to 25 years. The criterion measure was the scores obtained in Johnson’s Basketball test. Before administering the test, the subjects were briefed about the purpose of the study (To measure the ability of a player’s skill in dribbling and lay up shooting in basketball.) and details of the test were explained to them. The subjects were given a demonstration of the test by a trained helper. They were also given sufficient number of trials to enable them to become absolutely familiar with the test. To ensure uniform testing conditions, the subjects were tested in the morning and evening sessions after warming-up during practice sessions. The duration of test administration was set in a manner so that fatigue may not occur. The players being tested stood behind half court line, with a standard size basketball in his hands. One point was awarded for each successful basket. Three trials of the 10 lay-up shot attempts were given to each subject. Best of the 3 trials was the scores of the player. Lay up, Dribble and Lay up time and the composite scores of these two were calculated for further analysis. Analysis of data on Dribble and Lay up Shot test indicated that the constructed test in basketball was found to be reliable. The findings of the study further reveal that the Dribble and Lay up Shot test in basketball was found to be objective. The significant values showed that the directions for administration of the test were specific and clear for performance as well as evaluation. Finally the constructed test for the Dribble and Lay up shot was also found to be valid as the test items scores correlated significantly with the scores obtained in Johnson Basketball Test.

Dr. Baljinder Singh Bal, Dr. Nishan Singh Deol, Prof. Perminder Jeet Kaur, (2009) investigated the, **"Relationship of Kinematic Variables with the Performance of Basketball Players in Lay-up Shot."** The purpose of the study was to determine the relationship between selected kinematic variables and performance of lay-up shots. Five (N=5) male basketball players who represented Punjab Technical University, Jalandhar, were selected as subjects for the study. The help of digital photography was used to film the subjects in sagittal plane of lay-up shot. Joint point method was used in order to obtain the values of selected angular kinematic variables from developed stick figures. Height of center of Gravity was calculated by segmentation method. The performance in Lay –Up Shot was recorded by the scores in Lay –Up Shot, which was obtained by using a three point scale by the three judges. To determine the degree of relationship between selected kinematic variables with the performance in Layup Shot, Pearson's Product Moment Correlation Method was used. The results have shown the insignificant values of coefficient of correlation incase of all the selected kinematic variables and significant relationship between the height of center of gravity at the moment of release with the performance of the subjects in lay-up shots.

P. R. Phillips (1972) conducted a study on**, "A Comparison of Two Methods of Shooting The Lay-up Shot in Basketball Among College Women"**. The purpose of this study was to compare the overhand and underhand lay-up shots, among college women classified as beginning basketball players. Thirty-six subjects were divided into two groups and assigned either the overhand or underhand methods of shooting the lay-up shot. All subjects were administered a revised version of the bounce and shoot test to evaluate initial ability to execute a lay-up shot. Following this test, the two groups of subjects received instruction and practice in the lay-up shot and were tested again at periods of two and four Weeks after the initial test. A two factor analysis of variance for repeated measures was employed to analyze the data. The results showed no significant difference (p i. ,25) in accuracy and time scores between students executing an overhand lay-up shot and those performing an underhand shot following a four week instruction period. Both the overhand and underhand groups improved significantly (p = ,001) in shooting accuracy over this period. Based on the results of this study, it was concluded that beginning basketball students can be equally successful with either the overhand or underhand lay-up shot following a four week instruction period and can improve in shooting ability, using either technique, during this period.

2.4 Reviews on Parameters Related to this Study

Albert Puig-Divı, Carles Escalona-Marfil, Josep Maria Padulles-Riu, Albert Busquets, Xavier Padulles-Chando, Daniel Marcos-Ruiz, (2019) investigated the**, "Validity and Reliability of the Kinovea Program in Obtaining Angles and Distances Using Coordinates in 4 Perspectives."** The main objective of this study is to determine the validity of the Kinovea software compared to AutoCAD, and its intra and inter-rater reliability in obtaining coordinates data; a second objective is to compare their results at 4 different perspectives (90˚, 75˚, 60˚ and 45˚) and to assess the inter and intra rater reliability at each perspective. For this purpose, a wire structure figure in the shape of a human lower limb was designed and measured in AutoCAD; it was then recorded during a pendular motion with a video-camera placed at distance of 5 m and analyzed with Kinovea in the 4 perspectives (90˚, 75˚, 60˚ and 45˚). Each frame was examined by three observers who made two attempts. A multiple approach was applied involving the analysis of the systematic error, with a two-way ANOVA 2x4; the relative reliability with Intraclass Correlation Coefficient (ICC) and the Coefficient of Variance (CV) (95% confidence interval); and the absolute reliability with the Standard Error (SE). The results indicate that the Kinovea software is a valid and reliable tool that is able to measure accurately at distances up to 5 m from the object and at an angle range of 90˚–45˚. Nevertheless, for optimum results an angle of 90˚ is suggested.

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.

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.

C. H. Guzmán-Valdivia, A. Blanco-Ortega, M.A. Oliver-Salazar, J.L. Carrera-Escobedo, (2013) studied the, **"Therapeutic Motion Analysis of Lower Limbs Using**

Kinovea." In this paper, a therapeutic motion analysis for the lower limbs rehabilitation using Kinovea was presented. The motion analysis was performed mainly using computational tools instead of traditional sensors and special hardware. The position, velocity and acceleration in a rehabilitation for lower limbs was obtained through a new proposed method. The evaluation of the software and the test performed focused in the rehabilitation of lower limbs. For this particular study a healthy patient was proposed, but this work is not limited to make the same experiments for the upper limbs and the inclusion of a patient with stroke. The advantages demonstrated in this article can be an starting point to analyze fast systems of multiple degrees of freedom for rehabilitation purposes. This kind of systems have several advantages the principal is their cost. The motion detection using Kinovea allows evaluate the rehabilitation progress of the patient for achieve the best recovery. In this paper, they discuss the possibility to use Kinovea in rehabilitation movements for lower limbs. They used a webcam to record the movement of patient's leg. The detection and analysis was carry out using Kinovea with position markers to measure model based on a robot of two degrees of freedom was proposed. The results of position, velocity and acceleration for ankle and knee was presented in a XY plane. In addition, the angular angular positions of lower limbs. To find the angle of the hip and knee, a mathematical measure of hip and knee was obtained using the inverse kinematics of a 2RR robot.

Linthorne and Patel (2011) studied the, **"Optimum Projection Angle for Attaining Maximum Distance in a Soccer Punt Kick."** To produce the greatest horizontal distance in a punt kick the ball must be projected at an appropriate angle. Here, we investigated the optimum projection angle that maximises the distance attained in a punt kick by a soccer goalkeeper. Two male players performed many maximum-effort kicks using projection angles of between 10° and 90°. The kicks were recorded by a video camera at 100 Hz and a 2 D biomechanical analysis was conducted to obtain measures of the projection velocity, projection angle, projection height, ball spin rate, and foot velocity at impact. The player's optimum projection angle was calculated by substituting mathematical equations for the relationships between the projection variables into the equations for the aerodynamic flight of a soccer ball. The calculated optimum projection angles were in agreement with the player's preferred projection angles (40° and 44°). In projectile sports even a small dependence of projection velocity on projection angle is sufficient to produce a substantial shift in the optimum projection angle away from 45°. In the punt kicks studied here, the optimum projection angle was close to 45° because the projection velocity of the ball remained almost constant across all projection angles. This result is in contrast to throwing and jumping for maximum distance, where the projection velocity the athlete is able to achieve decreases substantially with increasing projection angle and so the optimum projection angle is well below 45°.

Amritpal S. and N. S. Deol (2010) studied the, **"Kinematic Analysis of Spikers of Volleyball."** The objective of the study was to analyze the volleyball spiking action used by the players. Correlation between players while performing same action and comparison between counter and quick spiker and inter relation of swing, hitting and ball speed were computed. Two normal frame video cameras were used in recording of four inter university level players. It was found that there were significant differences in some angular kinematical variables like ankle and elbow of counter and quick spiker. Differences were also found at knee and shoulder joint. Positive correlation also existed between counter spikers at different limbs of body.

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

A. S. Ruhal and G. S. Ruhal (2009) studied the, **"Relationship of Kinematic Variables with the Performance of Standing Broad Jump."** The purpose of investigation was to study the relationship of kinematic variables i.e., angle at knee joints, angle at ankle joints, Height of the c.g, angle of take-off and total time taken with the performance of standing broad jump. Subjects were randomly selected from J.N.V University, Jodhpur and M.D.S

University, Ajmer. The criterion measure used for the study was the performance in standing broad jump and selected kinematic variables were analyzed. To analyze the raw data coefficient of correlation (r) were calculated and results were compared with the help SPSS. Level of significance was set at 0.05. It was found that the selected kinematic variables were significantly related with the performance in broad jump. It was also found that the time take to perform the broad jump was not significantly related with performance in broad jump.

Gutierrez, Campos and Navarro (2009) have studied on, **"A Comparison of Two Landing Styles in a Two-Foot Vertical Jump."** The aim of this study was to identify the differences between the two styles. Twenty three subjects participated in the study, of whom fourteen were volleyball players and nine were basketball players. The jumping performances were video recorded and synchronized with two force platforms at 250 Hz. Two temporal periods of the take-off were defined according to reduction or increase in the radial distance between the center of gravity (C.G.) and the foot support (T - RDCG and T + RDCG, respectively). The findings produced no specific advantages when both styles were compared with respect to take-off velocity and consequently, to jump height, but take-off time was significantly shorter ($p < 0.001$) in the hop style take-off. However, this reduction was compensated for by greater time employed in the last step of the approach run ($p < 0.001$). When the step-close style was used, the vertical velocity of C.G. at the beginning of the take-off is significantly lower. Moreover, the mean vertical force developed during T - RDCG was reduced by -627.7 ± 251.1 N, thus lessening impact on the landing. Horizontal velocity at the end of the take-off is less when the step-close style is used ($p < 0.005$), suggesting that this style is better for jumps where it is necessary to move horizontally during the flight against an opponent.

S. K. Sharma and D. Retta (2009) analyzed the, **"Segmental Placement of Center of Gravity of Michael Fred Phelps in Track Start During Beijing Olympics."** The main purpose of this study was to find out the placement of center of gravity of different body segments of Michael Fred Phelps on track start position. To find out the scientific principles assist in determining the mechanics of motion to physical activities in order to obtain the most effective and efficient result. This guide the researcher in judging performance and for directing performance towards perfection with minimum expenditure of energy in the set reference of time, avoiding fatigue, excess of respiration, perspiration besides maintains poise and style with perfect synchronization. Phelps won 14 career Olympic medals, the most by any Olympians. This fact inspired the investigator to scientifically investigate the styles and techniques adopted by the Fred Phelps. For collecting the requisite information an observatory type of data sheet formatted by Dempster (1955) was used in this study. It was finalized that the c.g. falls on 2.45 on x-axis and -0.95 on y-axis.

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

Bridgetti & Linthorne (2006) have studied the **"Changes in Long Jump Take-off Technique with Increasing Run-up Speed."** The study was conducted to determine the influence of run-up speed on take-off technique in the long jump. Seventy-one jumps by an elite male long jumper were recorded in the sagittal plane by a high-speed video camera. The take-off technique used by the male long jumper in this study changed in response to systematic changes in his run-up speed. As the athlete increased his run-up speed, the jump distance and take-off speed increased, the optimum leg angle at touchdown remained almost unchanged, and the optimum take-off angle and takeoff duration steadily decreased. To achieve the greatest jump distance this athlete should use a run-up speed that is as fast as possible and plant the take-off leg at about 61º to the horizontal with a minimum of knee flexion. Although this study examined the influence of changes in run-up speed on the take-off technique of a single athlete, it is possible to generalise the results of the study. The mathematical models of Alexander (1990) and Seyfarth et al. (2000) have established that the relations between the technique variables that were observed in the present study arise from the mechanics of the system, and not from individual idiosyncrasies of technique. Therefore, similar relations to the ones presented here may be expected for other experienced long jumpers.

Fleisig, et al. (2006) analysed the, **"Kinetic Comparison Among the Fastball, Curveball, Change-Up and Slider in Collegiate Baseball Pitchers."** In this study they looked at the kinematic parameters of elbow flexion, wrist extension, shoulder external rotation, shoulder horizontal adduction, lateral trunk tilt, knee flexion, forward trunk tilt, pelvis angular velocity, upper trunk angular velocity, stride length, foot angle, and foot position. Kinetic parameters selected for evaluation included the forces applied by the trunk to the upper arm at the shoulder, torques applied by the trunk to the upper arm about the shoulder, forces applied by the upper arm to the forearm at the elbow, and torques applied by the upper arm to the forearm at the elbow.

Linthorne & Everett (2006) have investigated, **"The Release Angle That Maximizes the Distance Attained in a Long Soccer Throw-in".** One male soccer player performed maximum-effort throws using release angles of between 10 and 60 degrees, and the throws were analysed using 2-D video. The player's optimum release angle was calculated by substituting mathematical expressions for the measured relations between release speed, release height, and release angle into the equations for the flight of a spherical projectile. We found that the musculoskeletal structure of the player's body had a strong influence on the optimum release angle. When using low release angles the player released the ball with a greater release speed, and because the range of a projectile is strongly dependent on the release speed, this bias toward low release angles reduced the optimum release angle to about 30 degrees. Calculations showed that the distance of a throw may be increased by a few meters by launching the ball with a fast backspin, but the ball must be launched at a slightly lower release angle.

Linthorne, Bridgett and Guzman (2005) have studied on, **"Optimum Take-off Angle in the Long Jump."** In this study, they establish that the optimum take-off angle for a long jumper may be predicted by combining the equation for the range of a projectile in free flight with the measured relations between take-off speed, take-off height and take-off angle for the jumper. The prediction method was evaluated using video measurements of three experienced male long jumpers who performed maximum effort jumps over a wide range of take-off angles. To produce low take-off angles the jumpers used a long and fast run-up, whereas higher take-off angles were produced using a progressively shorter and slower run-up. For all three jumpers, the take-off speed decreased and the take-off height increased as the athlete jumped with a higher take-off angle. The calculated optimum take-off angles were in good agreement with the jumpers' competition take-off angles.

Loram L. C. et al. (2005) investigated the, **"Determinants of Ball Release Speed in Schoolboy Fast-Medium Bowlers in Cricket."** The investigators investigating determinants of ball release speed have examined the technique and anthropometry of fast bowlers with little work being done on muscular strength. The aim of our study was to determine whether knee biomechanics during bowling and strength of the shoulder and knee could predict ball release speed. For the study twelve cricketers, aged 16.6+/-0.7) years, from schools in Johannesburg, South Africa, volunteered for the study. Subjects were fast-medium bowlers (mean ball release speed of 29.2+/-1.8 m.s(-1)) and had been bowling for at least 5 years. Three accurate deliveries were filmed on an outdoor cricket pitch, in the sagittal plane with a high-speed digital camera recording at 250 frames per second. The mean ball release speed, knee angle at ball release and knee angle at front foot strike were determined using simple two-dimensional kinematics. On a separate day, peak concentric isokinetic muscle torque was measured for both knees and the dominant shoulder. The result shows that the ball release speed was positively correlated to a straight knee at front foot strike (r=0.72, P=0.009) and at ball release (r=0.71, P=0.011). No significant correlation was found between ball release speed and any of the peak torque values (knee extension peak torque, r=-0.11, knee flexion peak torque, r=-0.08, shoulder internal rotation peak torque, r=0.21 and shoulder external rotation, r=0.29, P>0.05). A multiple regression model using knee angle at front foot strike and at ball release, and the angle at which peak torque is generated during shoulder internal and external rotation, predicted ball release speed (adjusted r2=0.85, P<0.002). Lastly they conclude that the angle of the front knee at the beginning and end of a delivery is an important correlate of ball release speed in schoolboy fast-medium bowlers. In addition they have also demonstrated that a multiple regression model based on knee kinematics and shoulder peak torque angles can be used to predict ball release speed.

Wakai and Linthorne (2005) have studied on the, **"Optimum Take-off Angle in the Standing Long Jump."** The aim of this study was to identify and explain the optimum projection angle that maximizes the distance achieved in a standing long jump. Five physically active males performed maximum effort jumps over a wide range of take-off angles and the jumps were recorded and analyzed using a 2-D video analysis procedure. The total jump distance achieved was considered as the sum of three component distances (take-off, flight and landing), and the dependence of each component distance on the take-off angle was systematically investigated. The flight distance was strongly affected by a decrease in the jumper's take-off speed with increasing take-off angle and the take-off distance and landing distance steadily decreased with increasing take-off angle due to changes in jumper's body configuration. The optimum take-off angle for the jumper was the angle at which the three component distances combined to produce the greatest jump distance. Although the calculated optimum take-off angles (19-27°) were lower than the jumpers' preferred take-off angles (31-39°) the loss in jump distance through using a sub-optimum take-off angle was relatively small.

Chen and Zhang (2001) carried out a research that focused on, **"Kinematic Analysis on Take-off Technique of Chinese Elite Male High Jumpers."** The purpose of the study was to make an analysis on the takeoff technique of some excellent male high jumpers through three dimensional photographing. The result shows that there were significant differences in take-off technique between male Chinese high jumper and foreign one. The Chinese jumpers had a lower horizontal velocity in the last two steps and the fall in angle of their body range from big to small. During the take-off with the take-off leg touching the ground, they had a lower horizontal velocity and a shorter distance of vertical acceleration. The proportion of the buffer time to the stretch time of the take-off leg did not fully suit the laws of biomechanics. In addition, it was a common problem for our jumpers that the take-off leg did not fully stretch and swing leg has a lower swing speed and smaller amplitude.

Escamilla, Fleisig, Zheng, Barrentine & Andrews (2001) have studied the, **"Kinematic Comparisons of 1996 Olympic Baseball Pitchers."** In this study 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 analyzed while throwing the fastball pitch. Twenty-one kinematics 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 kinematics 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 is similar among Baseball pitchers from different countries.

Lees, Rojas, Cepero, Soto and Guttierrez (2000) have studied, **"How the Free Limbs are Used by Elite High Jumpers in Generating Vertical Velocity."** They analysed how elite high jumpers used their free limbs, in a competitive high jump and to estimate contribution the that these made to vertical take-off velocity. This was achieved by analyzing the competitive performances of six elite male high jumpers using 3-D motion analysis and assessing limb function using the relative momentum method. The mean peak relative momentum of the arm nearest to the bar at take-off was 9.4 kg ms-1, while that of the arm furthest away from the bar was 11.3 kg ms-1 and these did not differ significantly. The free leg-reached a mean peak relative momentum of 20.9 kg ms-1. At touch-down the free leg and a large positive relative momentum that was offset by the negative relative momentum of the arms, although their combined value still remained positive. The mean combined free limb's relative momentum at touch-down was 13.8 kg ms-1and reached a peak of 37.6 kg ms-1. The difference between these two values amounted to 7.1% of whole body momentum, which was judged to be the amount by which the free limbs contributed to the performance. The arms had a greater influence on performance than had the lead leg. This was because the lead leg increased its relative momentum little during the contact period at the same time as the arms had an initial negative momentum little during the contact period while the arms had an initial negative value that increased markedly after touch-down. The compressive force exerted by the motion of the free limbs, estimated by the change in the combined free limb's relative momentum, reached a mean peak of 366 N and was greatest at 37% of the contact period. It was concluded that to maximum the contribution the free limbs can make to performance, the arms should have a vigorous downward motion at touch-down to make the most use of the high relative momentum of the free (lead) leg.

B. Yuexin (1999) researched the, **"Horizontal-to-Vertical Velocity Conversion in the Triple Jump."** The aim of this study was to determine the effects of selected factors on horizontal-to-vertical velocity conversion in the triple jump. An understanding of this conversion is important not only for studies on the techniques of the triple jump, but also for other jumping events. Ten elite jumpers were studied. Three-dimensional kinematic data were collected for at least four complete trials in the same competition for each athlete. The loss in horizontal velocity and the gain in vertical velocity during each support phase were calculated for each trial. The loss in horizontal velocity was found to be a linear function of the gain in vertical velocity. The slope of this linear function, A1, is referred to as the horizontal-to-vertical velocity conversion coefficient. The loss in horizontal velocity increased as the gain in vertical velocity increased. The sensitivity of the loss in horizontal velocity to the gain in vertical velocity increased as the magnitude of A1 increased.

Knudson & Blackwell (1997) examined the, **"Upper Extremity Angular Kinematics of the One-Handed Backhand Drive in Tennis Players with and Without Tennis Elbow."** They determined the Wrist and elbow angular kinematics and racket acceleration at impact were measured in the Tennis one-handed back-hand drive for three groups of players: Professionals with no history of Tennis elbow (PRO), intermediates with no history of Tennis elbow (- TE), and intermediates with a history of Tennis elbow (+ TE). Electrogoniometer, strain gauge, and accelerometer signals were sampled for thirty strokes at 1000 Hz. The first ten strokes with central impacts were analyzed. Angular kinematics and racket acceleration at impact were analyzed with planned comparisons ANOVA. A significant ($p < 0.05$) difference in mean wrist angular velocity after impact was observed between the PRO group (-4.04 rad/s of extension) and the + TE group (0.42 rad/s of flexion). No significant differences were observed in impact acceleration or elbow angular kinematics. Eccentric wrist extensor muscular actions through impact may be important area of study for one-handed backhands and TE.

Hore, Watts, & Martin, (1996) have studied on **"Finger Flexion does not Contribute to Ball Speed in Over-Arm Throws"**. The aim of this study was to determine whether, in over-arm throws made by recreational ball players, the fingers undergo flexion movement before ball release and thereby contribute to the generation of ball speed. To obtain the high resolution needed to answer this question, the magnetic-field search-coil technique was used and the data were sampled at 1000 Hz. The subjects, who were either seated or were standing, threw tennis balls at different speeds at a target. Angular positions in three dimensions were simultaneously recorded of the distal phalanx of the middle finger and hand and, in additional experiments to determine the mechanism of ball release in more detail, three middle finger phalanges and the hand. Different phases of ball release were determined by pressure-sensitive micro switches on the proximal and distal phalanges of the middle finger. Irrespective of whether the subjects were seated or were standing, for all throws at all speeds, finger flexion did not occur before ball release. That is, up until final release of the ball, the fingers only underwent extension associated with hand opening. For fast throws, at the instant of final ball release the fingers began to flex, presumably as a result of reactive forces associated with release of the ball. Thus, in over-arm throws made by recreational ball players, finger flexion movement does not appear to contribute to the generation of ball speed.

Dapena and Chung (1988) have studied the, **"Vertical and Radial Motions of the Body During the Take-off Phase of High Jumping."** Film analysis of seven high jumpers showed that the radial velocity of the center of mass (COM) with respect to the supporting foot was more negative or less positive than the vertical velocity throughout the take-off phase. This favored faster eccentric or slower concentric conditions of the leg muscles. The radial distance from the hip of the take-off leg to the center of mass (RG/H) first decreased by 0.030 m, due to negative radial motions of the arms and swinging leg. This contributed to a smaller negative radial velocity of the hip (VRH) and thus to slower eccentric conditions of the muscles of the take-off leg. Therefore, it may have helped to cushion the first impact with the ground. Subsequently, RG/H increased by 0.120 m, due to positive radial velocities of the arms, the swinging leg and the head and trunk. This contributed first to larger negative (and later to smaller positive) VRH values and thus to faster eccentric and slower concentric conditions of the muscles of the take-off leg.

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

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

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

2.5 Summary of Literature

The review of literature helped the researcher to spot out relevant topics and variables. Further, the literature helped the researcher to frame the suitable hypothesis leading to the problems. The latest literature also helped the investigator to support his work.

It was also observed from the review of literature that there are no research studies that are directly related to the present study in analyzing selected variables which are contributed to the performance. This inference has motivated the researcher to undertake this study.

CHAPTER 3

METHODOLOGY

Chapter-III

METHODOLOGY

This chapter described the selection of subjects, selection of variables, criterion measure, instruments and tools used, testers reliability, instruments reliability, reliability of the data, 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.

3.1 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

3.2 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.

3.3 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.

3.4 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**

3.5 Testers Reliability

Recording of the movements and analysis of the recorded movements were done by technical and competent person.

3.6 Instruments Reliability

- Standard cameras were used to record the movement of the spike and jump service technique (Nikon D3300 and Nikon D5100).
- Standard software (Kinovea-0.8.24) was used to analyze the recorded movements and to measure the kinematic variables.

3.7 Reliability of Data

To obtain the measurements of the variables, standard and calibrated equipments like Digital Video Cameras, Steel tape and specialized motion analyzing software (Kinovea 0.8.24) were used. All the equipments and software were supplied by standard agencies and companies and their accuracy was ensured by the experts and suppliers. All the measurements pertaining to the kinematical variables were taken by the researcher under the expert's guidance. Digital video cameras (Nikon D3300 and Nikon D5100), were operated by expert professional videographers. So, the data collected by using these instruments and software were considered reliable for the purpose of this study.

3.8 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.

3.9 Procedure for Collecting Data

3.9.1 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.

3.9.2 Recording of Movements

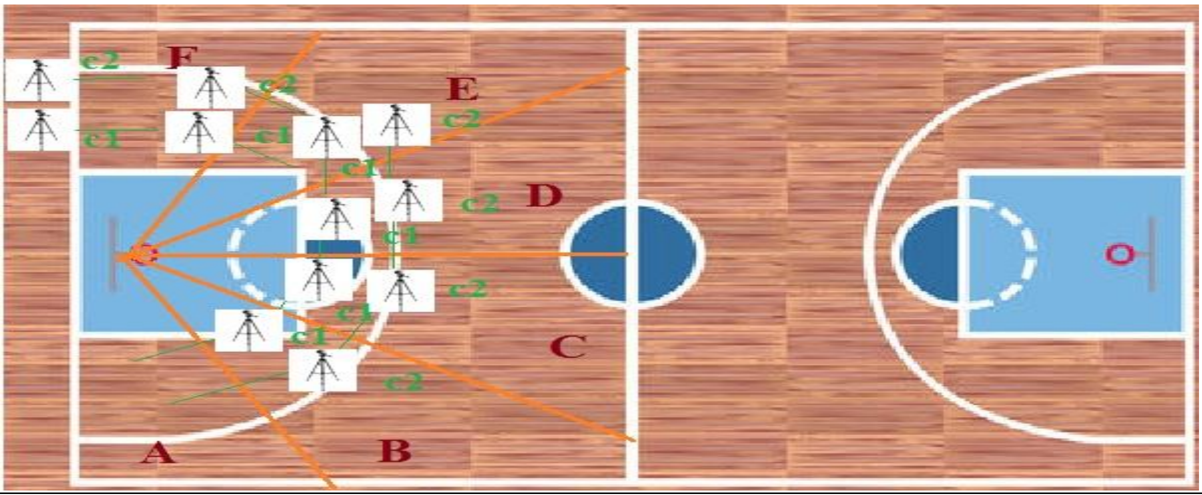
The recording of layup shots from different field positions of the selected subjects (National Level male and female basketball players) was done at the basketball ground of the Jadavpur University-Main Campus. Before starting the recording of movements, the purpose of the recording was briefly explained 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.



Photograph 4: Filming Environment for the Data Collection

Photograph 5: Reference Scale

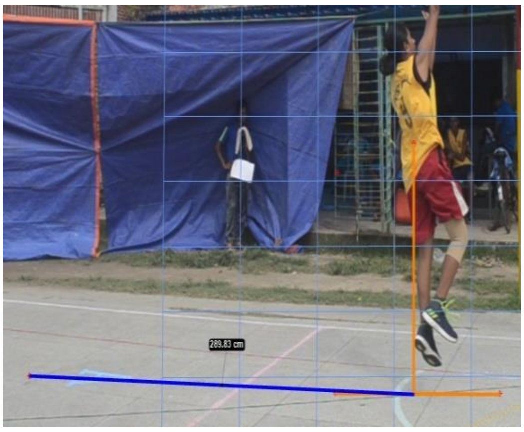
Photograph 6: Reference Scale in vertical position

Photograph 7: Reference Scale in horizontal position

3.9.3 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.

A. **TWO AND HALF STEP LENGTH:** To measure the two and a half step length in lay-up with the help of motion analysis software (Kinovea) at first, a point marker was set on the toe of the subject when he was going for the lay-up. Then another point marker was set on the ground which was a vertical point from the Cg of the subject just when he was releasing the ball for the basket. The distance between the two markers was measured and recorded as the two and half step length.

	
Photograph 8: Measurement of Two and Half Step Length (Male)	**Photograph 9: Measurement of Two and Half Step Length (Female)**

B. APPROACH SPEED: The approach speed in lay-up shot is the speed of the subject approaching for lay-up. For measuring the approach speed last three consecutive phases were taken immediately before the subjects began their lay-up shot. The horizontal displacement of the approach speed was measured from the reference scale by using the software and time information was obtained from the basic frequency of the camera. By this information approach speed was measured.

	
Photograph 10: Measurement of Approach Speed (Male)	**Photograph 11: Measurement of Approach Speed (Female)**

C. TAKE OFF VELOCITY (VERTICAL AND HORIZONTAL): Take off velocity is the displacement of Cg of the subject by the time taken at take-off. To measure the horizontal and vertical velocities at take-off, the last two consecutive phases of the take-off were taken. And then from the software the horizontal and vertical displacement of the Cg, angle of movement, and time difference for two phases were measured. By this information, horizontal and vertical velocity was measured.

Photograph 12: Measurement of Take off Velocity (Male)

Photograph 13: Measurement of Take off Velocity (Female)

Photograph 14: Measurement of Take off Velocity (Male)

Photograph 15: Measurement of Take off Velocity (Female)

D. TAKE OFF ANGLE: To measure the take-off angle firstly the position of Cg was identified. Then the angle of Cg from the ground at the time of take-off was measured as the take-off angle.

	
Photograph 16: Measurement of Take off Angle (Male)	**Photograph 17: Measurement of Take off Angle (Female)**

E. **HEIGHT OF BALL RELEASE:** The vertical distance between the point of release of the basketball and the floor of the basketball court at the time of releasing the basketball layup was measured and captured as the height of the ball release.

	
Photograph 18: Measurement of Height of Ball Release (Male)	**Photograph 19: Measurement of Height of Ball Release (Female)**

F. **ANGLE OF BALL RELEASE:** This is the angle, relative to the ground, at which the basketball was projected into the air at the time of release. The angle of ball release was calculated by deliberating the angle of the basketball projection, in a single consecutive phase at the time of releasing the ball for the basket.

Photograph 20: Measurement of Angle of Ball Release (Male)	Photograph 21: Measurement of Angle of Ball Release (Female)

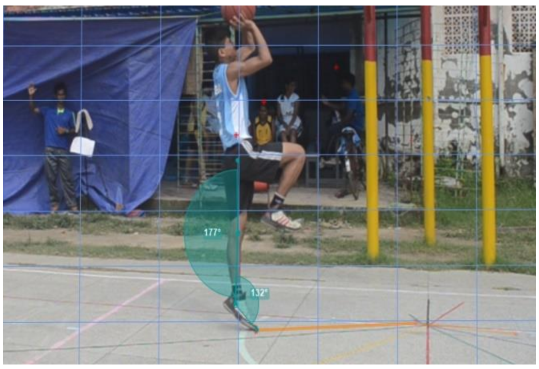
G. **SPEED OF BALL RELEASE:** For this measurement, at first, the center point position of the basketball at the time of release was identified. Then the movement of this center point of the basketball for one consecutive phase at release was taken and these two points were added by a line and the distance between the two points was taken. Then the time information for travelling distance was measured by the frequency of the camera and by these two information the speed of ball release was measured.

Photograph 22: Measurement of Speed of Ball Release (Male)	Photograph 23: Measurement of Speed of Ball Release (Female)

H. **SEGMENTAL JOINT ANGULAR VELOCITY AT RELEASE:** On the basis of the application of the marking technique in the motion analysis software (Kinovea), the selected videos were developed. All segmental joint angles were calculated when the subject was releasing the basketball for the basket. For these angle measurements the positions of the joints for two consecutive phases at the time of releasing the ball for the basket were taken. In order to receive the complete segmental angles, the angle markers were set in different marked points on the various joints. After completing the marking by joining different highlighted marks on the selected body joints software automatically present the measurements of required angles. Different segments were drawn to find out different angles of the joints at the time of layup. For the knee joint, a segment was drawn from the ankle joint to the hip joint through the knee joint. For the ankle joint, a segment was drawn from the toe to the knee joint through the ankle joint. For the shoulder joint, a segment was drawn from the hip joint to the elbow joint through the shoulder joint. For the elbow joint, a segment was drawn from shoulder joint to wrist joint through elbow joint. And for wrist joint a segment was drawn from elbow joint to fingertip through wrist joint.

Photograph 24: Measurement of Segmental Joint Angular Velocity at Release in First Phase [Ankle & Knee] (Male)

Photograph 25: Measurement of Segmental Joint Angular Velocity at Release in First Phase [Ankle & Knee] (Female)



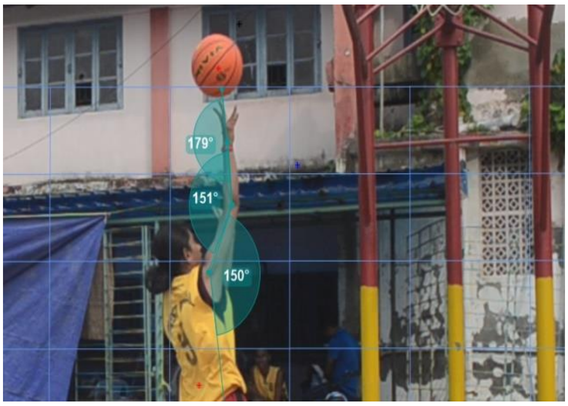
Photograph 26: Measurement of Segmental Joint Angular Velocity at Release in Last Phase [Ankle & Knee] (Male)

Photograph 27: Measurement of Segmental Joint Angular Velocity at Release in Last Phase [Ankle & Knee] (Female)

Photograph 28: Measurement of Segmental Joint Angular Velocity at Release in First Phase [Shoulder, Elbow & Wrist] (Male)

Photograph 29: Measurement of Segmental Joint Angular Velocity at Release in First Phase [Shoulder, Elbow & Wrist] (Female)

Photograph 30: Measurement of Segmental Joint Angular Velocity at Release in Last Phase [Shoulder, Elbow & Wrist] (Male)



Photograph 31: Measurement of Segmental Joint Angular Velocity at Release in Last Phase [Shoulder, Elbow & Wrist] (Female)

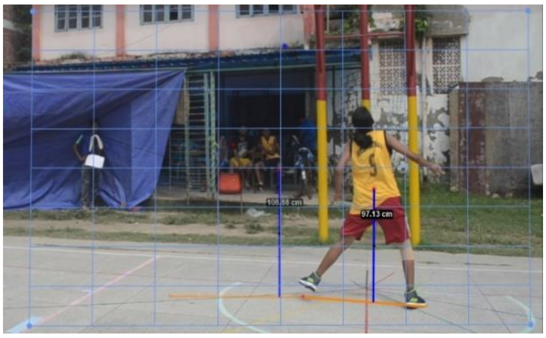
I. **DURATION OF TOTAL FLIGHT:** This was the time taken from the complete leaving of the take-off foot at the last phase of take-off to the ground touch of the foot at the first phase of landing.

Photograph 32: Measurement of Duration of Total Flight (Male)

Photograph 33: Measurement of Duration of Total Flight Female)

J. **LOWERING OF C.G:** For this measurement at first, the height of the Cg of the subjects was calculated at the first phase of landing by using the software. Again, this measurement was taken when the subjects were completely stable with both of their feet, that is the maximum lowering point of the Cg. Then the subtraction between the first and last measurement was deliberated as the lowering of Cg.

Photograph 34: Measurement of Lowering of CG (Male)



Photograph 35: Measurement of Lowering of CG (Female)

3.10 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.

CHAPTER 4

RESULTS AND DISCUSSIONS

Chapter-IV

RESULTS AND DISCUSSIONS

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

4.1 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.

4.2 Presentation and Analysis of Data

The anthropometric characteristics of the national basketball players (Male) have presented in table 1.

Table 1 Anthropometric Description of the Selected National Basketball Players (Male)

Anthropometric Description for Male Basketball Players						
Subject	Age (year)	Height (cm)	Weight (kg)	Two Hand Distance (cm)	Arm Length (cm)	Leg Length (cm)
M1	15	174	54.5	162	73	102
M2	16	181	55.5	180	76	106
M3	16	178	71	177	74	105
M4	21	178	78	173	75	100
M5	21	185	68	186	80	111

The anthropometric characteristics of the national basketball players (Female) have presented in table 2.

Table 2 Anthropometric Description of the Selected National Basketball Players (Female)

Anthropometric Description for Female Basketball Players						
Subject	Age (year)	Height (cm)	Weight (kg)	Two Hand Distance (cm)	Arm Length (cm)	Leg Length (cm)
F1	21	162	54	158	73	89
F2	17	158	48	154	68	87
F3	16	168	57	164	75	95
F4	15	175	79	179	83	100
F5	21	162	65	161	69	94

Data Regarding All the Variables for Male Basketball Players have given in Table from 3 to 18.

Data regarding approach speed have presented in table 3.1 and 3.2

Table 3.1: Descriptive Analysis of Approach Speed with Respect to Different Zones

					95% Confidence Interval for Mean	
Zones	N	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound
A	5	3.1940	.66357	.29676	2.3701	4.0179
B	5	3.6740	.49632	.22196	3.0577	4.2903
C	5	3.5360	.58226	.26040	2.8130	4.2590
D	5	3.4280	.61308	.27418	2.6668	4.1892
E	5	3.5320	.40370	.18054	3.0307	4.0333
F	5	4.0020	.29778	.13317	3.6323	4.3717
Total	30	3.5610	.53878	.09837	3.3598	3.7622

Table 3.2 ANOVA Table for the Data on Approach Speed

	Sum of Squares	df	Mean Square	F	P value
Between Groups	1.805	5	.361	1.311	.293
Within Groups	6.613	24	.276		
Total	8.418	29			

The result of ANOVA Table 3.2 reveals that there was no significant difference exists in approach speed of layup shot in basketball concerning different zones of the two-point field goal area. (f>0.05)

Data regarding two and half step length have presented in table 4.1 and 4.2

Table 4.1: Descriptive Analysis of Two and Half Step Length with Respect to Different Zones

					95% Confidence Interval for Mean	
Zones	N	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound
A	5	3.4520	.44589	.19941	2.8984	4.0056
B	5	3.8720	.47177	.21098	3.2862	4.4578
C	5	3.5940	.32822	.14679	3.1865	4.0015
D	5	3.7120	.27179	.12155	3.3745	4.0495
E	5	3.8780	.45450	.20326	3.3137	4.4423
F	5	3.5360	.73989	.33089	2.6173	4.4547
Total	30	3.6740	.46286	.08451	3.5012	3.8468

Table 4.2 ANOVA Table for the Data on Two and Half Step Length

	Sum of Squares	df	Mean Square	F	P value
Between Groups	.785	5	.157	.694	.633
Within Groups	5.428	24	.226		
Total	6.213	29			

The result of ANOVA Table 4.2 reveals that there was no significant difference exists in two and half step length of layup shot in basketball concerning different zones of the two-point field goal area. (f>0.05)

Data regarding takeoff velocity have presented in table 5.1 and 5.2

Table 5.1: Descriptive Analysis of Takeoff Velocity with Respect to Different Zones

Zones	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
A	5	3.7540	.27107	.12123	3.4174	4.0906
B	5	3.7320	.51795	.23163	3.0889	4.3751
C	5	3.6120	.10330	.04620	3.4837	3.7403
D	5	3.3760	.43884	.19625	2.8311	3.9209
E	5	3.8940	.35451	.15854	3.4538	4.3342
F	5	3.5400	.51220	.22906	2.9040	4.1760
Total	30	3.6513	.39656	.07240	3.5033	3.7994

Table 5.2 ANOVA Table for the Data on Takeoff Velocity

	Sum of Squares	df	Mean Square	F	P value
Between Groups	.828	5	.166	1.065	.404
Within Groups	3.732	24	.156		
Total	4.561	29			

The result of ANOVA Table 5.2 reveals that there was no significant difference exists in takeoff velocity of layup shot in basketball concerning different zones of the two-point field goal area. (f>0.05)

Data regarding vertical velocity have presented in table 6.1 and 6.2

Table 6.1: Descriptive Analysis of Vertical Velocity with Respect to Different Zones

Zones	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
A	5	2.6020	.32136	.14371	2.2030	3.0010
B	5	2.4560	.33336	.14908	2.0421	2.8699
C	5	2.3180	.32260	.14427	1.9174	2.7186
D	5	2.0680	.35926	.16067	1.6219	2.5141
E	5	2.4760	.44202	.19768	1.9272	3.0248
F	5	2.1960	.36977	.16537	1.7369	2.6551
Total	30	2.3527	.37567	.06859	2.2124	2.4929

Table 6.2 ANOVA Table for the Data on Vertical Velocity

	Sum of Squares	df	Mean Square	F	P value
Between Groups	.974	5	.195	1.499	.227
Within Groups	3.119	24	.130		
Total	4.093	29			

The result of ANOVA Table 6.2 reveals that there was no significant difference exists in vertical velocity of layup shot in basketball concerning different zones of the two-point field goal area. (f>0.05)

Data regarding horizontal velocity have presented in table 7.1 and 7.2

Table 7.1: Descriptive Analysis of Horizontal Velocity with Respect to Different Zones

Zones	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
A	5	2.6980	.22454	.10042	2.4192	2.9768
B	5	2.7900	.53796	.24058	2.1220	3.4580
C	5	2.7520	.29389	.13143	2.3871	3.1169
D	5	2.6580	.35471	.15863	2.2176	3.0984
E	5	3.0020	.12795	.05722	2.8431	3.1609
F	5	2.7520	.61112	.27330	1.9932	3.5108
Total	30	2.7753	.37736	.06890	2.6344	2.9162

Table 7.2 ANOVA Table for the Data on Horizontal Velocity

	Sum of Squares	df	Mean Square	F	P value
Between Groups	.362	5	.072	.461	.801
Within Groups	3.767	24	.157		
Total	4.130	29			

The result of ANOVA Table 7.2 reveals that there was no significant difference exists in horizontal velocity of layup shot in basketball concerning different zones of the two-point field goal area. (f>0.05)

Data regarding takeoff angle have presented in table 8.1 and 8.2

Table 8.1: Descriptive Analysis of Takeoff Angle with Respect to Different Zones

					95% Confidence Interval for Mean	
Zones	N	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound
A	5	99.800	2.7749	1.2410	96.355	103.245
B	5	98.200	3.7683	1.6852	93.521	102.879
C	5	98.600	3.0496	1.3638	94.813	102.387
D	5	95.400	2.7019	1.2083	92.045	98.755
E	5	96.200	3.8987	1.7436	91.359	101.041
F	5	97.000	4.4159	1.9748	91.517	102.483
Total	30	97.533	3.5207	.6428	96.219	98.848

Table 8.2 ANOVA Table for the Data on Takeoff Angle

	Sum of Squares	df	Mean Square	F	P value
Between Groups	66.667	5	13.333	1.093	.390
Within Groups	292.800	24	12.200		
Total	359.467	29			

The result of ANOVA Table 8.2 reveals that there was no significant difference exists in takeoff angle of layup shot in basketball concerning different zones of the two-point field goal area. (f>0.05)

Data regarding height of ball release have presented in table 9.1 and 9.2

Table 9.1: Descriptive Analysis of Height of Ball Release with Respect to Different Zones

Zones	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
A	5	2.8660	.18366	.08213	2.6380	3.0940
B	5	2.8180	.25233	.11285	2.5047	3.1313
C	5	2.8080	.15418	.06895	2.6166	2.9994
D	5	2.8280	.15802	.07067	2.6318	3.0242
E	5	2.7900	.09460	.04231	2.6725	2.9075
F	5	2.6080	.20608	.09216	2.3521	2.8639
Total	30	2.7863	.18543	.03385	2.7171	2.8556

Table 9.2 ANOVA Table for the Data on Height of Ball Release

	Sum of Squares	df	Mean Square	F	P value
Between Groups	.207	5	.041	1.256	.315
Within Groups	.790	24	.033		
Total	.997	29			

The result of ANOVA Table 9.2 reveals that there was no significant difference exists in height of ball release of layup shot in basketball concerning different zones of the two-point field goal area. (f>0.05)

Data regarding angle of ball release have presented in table 10.1 and 10.2

Table 10.1: Descriptive Analysis of Angle of Ball Release with Respect to Different Zones

Zones	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
A	5	57.200	12.0083	5.3703	42.290	72.110
B	5	56.200	11.3446	5.0735	42.114	70.286
C	5	60.000	11.2250	5.0200	46.062	73.938
D	5	64.600	10.2372	4.5782	51.889	77.311
E	5	54.200	7.1903	3.2156	45.272	63.128
F	5	64.000	3.3166	1.4832	59.882	68.118
Total	30	59.367	9.6828	1.7678	55.751	62.982

Table 10.2 ANOVA Table for the Data on Angle of Ball Release

	Sum of Squares	df	Mean Square	F	P value
Between Groups	453.367	5	90.673	.961	.461
Within Groups	2265.600	24	94.400		
Total	2718.967	29			

The result of ANOVA Table 10.2 reveals that there was no significant difference exists in angle of ball release of layup shot in basketball concerning different zones of the two-point field goal area. (f>0.05)

Data regarding speed of ball release have presented in table 11.1 and 11.2

Table 11.1: Descriptive Analysis of Speed of Ball Release with Respect to Different Zones

Zones	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
A	5	2.9460	.96749	.43267	1.7447	4.1473
B	5	3.5340	.44618	.19954	2.9800	4.0880
C	5	2.7520	.80503	.36002	1.7524	3.7516
D	5	2.5100	.53991	.24145	1.8396	3.1804
E	5	3.9620	.56153	.25113	3.2648	4.6592
F	5	3.1840	.80208	.35870	2.1881	4.1799
Total	30	3.1480	.81412	.14864	2.8440	3.4520

Table 11.2 ANOVA Table for the Data on Speed of Ball Release

	Sum of Squares	df	Mean Square	F	P value
Between Groups	7.088	5	1.418	2.804	.039
Within Groups	12.133	24	.506		
Total	19.221	29			

The result of ANOVA Table 11.2 shows that there was significant difference exists in speed of ball release of layup shot in basketball concerning different zones of the two-point field goal area. (f<0.05) Further to identify which particular differences between pairs of means were significant, the Post hoc comparison of means using LSD test was used.

Table 11.3 represents the Post hoc comparison of means using LSD test on Speed of Ball Release.

Table 11.3 Post hoc Comparison of Means Using LSD Test on Speed of Ball Release

(I) zone 1	(J) zone 1	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
A	B	-.58800	.44969	.203	-1.5161	.3401
	C	.19400	.44969	.670	-.7341	1.1221
	D	.43600	.44969	.342	-.4921	1.3641
	E	-1.01600*	.44969	.033	-1.9441	-.0879
	F	-.23800	.44969	.601	-1.1661	.6901
B	A	.58800	.44969	.203	-.3401	1.5161
	C	.78200	.44969	.095	-.1461	1.7101
	D	1.02400*	.44969	.032	.0959	1.9521
	E	-.42800	.44969	.351	-1.3561	.5001
	F	.35000	.44969	.444	-.5781	1.2781
C	A	-.19400	.44969	.670	-1.1221	.7341
	B	-.78200	.44969	.095	-1.7101	.1461
	D	.24200	.44969	.595	-.6861	1.1701
	E	-1.21000*	.44969	.013	-2.1381	-.2819
	F	-.43200	.44969	.346	-1.3601	.4961
D	A	-.43600	.44969	.342	-1.3641	.4921
	B	-1.02400*	.44969	.032	-1.9521	-.0959
	C	-.24200	.44969	.595	-1.1701	.6861
	E	-1.45200*	.44969	.004	-2.3801	-.5239
	F	-.67400	.44969	.147	-1.6021	.2541
E	A	1.01600*	.44969	.033	.0879	1.9441
	B	.42800	.44969	.351	-.5001	1.3561
	C	1.21000*	.44969	.013	.2819	2.1381
	D	1.45200*	.44969	.004	.5239	2.3801
	F	.77800	.44969	.096	-.1501	1.7061
F	A	.23800	.44969	.601	-.6901	1.1661
	B	-.35000	.44969	.444	-1.2781	.5781
	C	.43200	.44969	.346	-.4961	1.3601
	D	.67400	.44969	.147	-.2541	1.6021
	E	-.77800	.44969	.096	-1.7061	.1501

*. The mean difference was significant at the 0.05 level.

Data regarding angular velocity of ankle have presented in table 12.1 and 12.2

Table 12.1: Descriptive Analysis of Angular Velocity of Ankle with Respect to Different Zones

Zones	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
A	5	8.3760	1.22028	.54573	6.8608	9.8912
B	5	8.1140	.77771	.34780	7.1483	9.0797
C	5	7.5480	3.09532	1.38427	3.7046	11.3914
D	5	8.5080	2.98085	1.33308	4.8068	12.2092
E	5	7.0680	2.59537	1.16068	3.8454	10.2906
F	5	7.5040	2.58303	1.15516	4.2967	10.7113
Total	30	7.8530	2.22743	.40667	7.0213	8.6847

12.2 ANOVA Table for the Data on Angular Velocity of Ankle

	Sum of Squares	df	Mean Square	F	P value
Between Groups	8.009	5	1.602	.283	.918
Within Groups	135.873	24	5.661		
Total	143.882	29			

The result of ANOVA Table 12.2 reveals that there was no significant difference exists in angular velocity of ankle of layup shot in basketball concerning different zones of the two-point field goal area. (f>0.05)

Data regarding angular velocity of knee have presented in table 13.1 and 13.2

Table 13.1: Descriptive Analysis of Angular Velocity of Knee with Respect to Different Zones

Zones	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
A	5	8.5060	.87125	.38964	7.4242	9.5878
B	5	7.6360	1.85203	.82825	5.3364	9.9356
C	5	7.9400	.76345	.34142	6.9921	8.8879
D	5	6.9360	.95715	.42805	5.7475	8.1245
E	5	6.5460	1.01202	.45259	5.2894	7.8026
F	5	8.9900	2.39407	1.07066	6.0174	11.9626
Total	30	7.7590	1.56607	.28592	7.1742	8.3438

Table 13.2 ANOVA Table for the Data on Angular Velocity of Knee

	Sum of Squares	df	Mean Square	F	P value
Between Groups	21.350	5	4.270	2.059	.106
Within Groups	49.775	24	2.074		
Total	71.125	29			

The result of ANOVA Table 13.2 reveals that there was no significant difference exists in angular velocity of knee of layup shot in basketball concerning different zones of the two-point field goal area. (f>0.05)

Data regarding angular velocity of shoulder have presented in table 14.1 and 14.2

Table 14.1: Descriptive Analysis of Angular Velocity of Shoulder with Respect to Different Zones

					95% Confidence Interval for Mean	
Zones	N	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound
A	5	6.0200	2.67792	1.19760	2.6949	9.3451
B	5	4.7980	1.61876	.72393	2.7880	6.8080
C	5	5.1940	1.44140	.64461	3.4043	6.9837
D	5	5.1500	.73181	.32728	4.2413	6.0587
E	5	4.5820	1.93312	.86452	2.1817	6.9823
F	5	4.4940	1.59915	.71516	2.5084	6.4796
Total	30	5.0397	1.68778	.30815	4.4094	5.6699

Table 14.2 ANOVA Table for the Data on Angular Velocity of Shoulder

	Sum of Squares	df	Mean Square	F	P value
Between Groups	7.813	5	1.563	.501	.772
Within Groups	74.796	24	3.117		
Total	82.609	29			

The result of ANOVA Table 14.2 reveals that there was no significant difference exists in angular velocity of shoulder of layup shot in basketball concerning different zones of the two-point field goal area. (f>0.05)

Data regarding angular velocity of elbow have presented in table 15.1 and 15.2

Table 15.1: Descriptive Analysis of Angular Velocity of Elbow with Respect to Different Zones

Zones	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
A	5	8.1180	5.10245	2.28188	1.7825	14.4535
B	5	4.9320	4.71772	2.10983	-.9258	10.7898
C	5	3.9700	2.96606	1.32646	.2872	7.6528
D	5	5.0180	1.93628	.86593	2.6138	7.4222
E	5	7.7220	4.33293	1.93775	2.3420	13.1020
F	5	3.7100	3.98232	1.78095	-1.2347	8.6547
Total	30	5.5783	4.03074	.73591	4.0732	7.0834

Table 15.2 ANOVA Table for the Data on Angular Velocity of Elbow

	Sum of Squares	df	Mean Square	F	P value
Between Groups	89.272	5	17.854	1.122	.375
Within Groups	381.887	24	15.912		
Total	471.158	29			

The result of ANOVA Table 15.2 reveals that there was no significant difference exists in angular velocity of elbow of layup shot in basketball concerning different zones of the two-point field goal area. (f>0.05)

Data regarding angular velocity of wrist have presented in table 16.1 and 16.2

Table 16.1: Descriptive Analysis of Angular Velocity of Wrist with Respect to Different Zones

Zones	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
A	5	5.4980	4.56886	2.04326	-.1750	11.1710
B	5	4.8880	6.30931	2.82161	-2.9460	12.7220
C	5	3.8380	2.38239	1.06544	.8799	6.7961
D	5	5.2360	1.66037	.74254	3.1744	7.2976
E	5	4.9740	3.82182	1.70917	.2286	9.7194
F	5	6.1080	2.81513	1.25897	2.6126	9.6034
Total	30	5.0903	3.62374	.66160	3.7372	6.4435

Table 16.2 ANOVA Table for the Data on Angular Velocity of Wrist

	Sum of Squares	df	Mean Square	F	P value
Between Groups	14.229	5	2.846	.186	.965
Within Groups	366.583	24	15.274		
Total	380.812	29			

The result of ANOVA Table 16.2 reveals that there was no significant difference exists in angular velocity of wrist of layup shot in basketball concerning different zones of the two-point field goal area. (f>0.05)

Data regarding duration of total flight have presented in table 17.1 and 17.2

Table 17.1: Descriptive Analysis of Duration of Total Flight with Respect to Different Zones

Zones	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
A	5	.6240	.08764	.03919	.5152	.7328
B	5	.6080	.05215	.02332	.5432	.6728
C	5	.6400	.07483	.03347	.5471	.7329
D	5	.6080	.05933	.02653	.5343	.6817
E	5	.5760	.06066	.02713	.5007	.6513
F	5	.5520	.06573	.02939	.4704	.6336
Total	30	.6013	.06847	.01250	.5758	.6269

Table 17.2 ANOVA Table for the Data on Duration of Total Flight

	Sum of Squares	df	Mean Square	F	P value
Between Groups	.026	5	.005	1.128	.373
Within Groups	.110	24	.005		
Total	.136	29			

The result of ANOVA Table 17.2 reveals that there was no significant difference exists in duration of total flight of layup shot in basketball concerning different zones of the two-point field goal area. (f>0.05)

Data regarding lowering of C.G have presented in table 18.1 and 18.2

Table 18.1: Descriptive Analysis of Lowering of C.G with Respect to Different Zones

Zones	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
A	5	.2960	.06229	.02786	.2187	.3733
B	5	.2620	.09757	.04363	.1409	.3831
C	5	.2300	.06042	.02702	.1550	.3050
D	5	.2360	.03975	.01778	.1866	.2854
E	5	.2420	.02168	.00970	.2151	.2689
F	5	.2500	.06042	.02702	.1750	.3250
Total	30	.2527	.06028	.01101	.2302	.2752

Table 18.2 ANOVA Table for the Data on Lowering of C.G

	Sum of Squares	df	Mean Square	F	P value
Between Groups	.014	5	.003	.759	.588
Within Groups	.091	24	.004		
Total	.105	29			

The result of ANOVA Table 17.2 reveals that there was no significant difference exists in lowering of C.G of layup shot in basketball concerning different zones of the two-point field goal area. (f>0.05)

Data Regarding All the Variables for Female Basketball Players have given in Table from 19 to 34.

Data regarding approach speed have presented in table 19.1 and 19.2

Table 19.1: Descriptive Analysis of Approach Speed with Respect to Different Zones

Zones	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
A	5	3.2920	.22387	.10012	3.0140	3.5700
B	5	3.1620	.14132	.06320	2.9865	3.3375
C	5	2.7720	.16873	.07546	2.5625	2.9815
D	5	3.0040	.32067	.14341	2.6058	3.4022
E	5	3.2300	.23885	.10682	2.9334	3.5266
F	5	2.9680	.39239	.17548	2.4808	3.4552
Total	30	3.0713	.29851	.05450	2.9599	3.1828

Table 19.2 ANOVA Table for the Data on Approach Speed

	Sum of Squares	df	Mean Square	F	P value
Between Groups	.935	5	.187	2.719	.044
Within Groups	1.650	24	.069		
Total	2.584	29			

The result of ANOVA Table 19.2 shows that there was significant difference exists in approach speed of layup shot in basketball concerning different zones of the two-point field goal area. ($f<0.05$) Further to identify which particular differences between pairs of means were significant, the Post hoc comparison of means using LSD test was used.

Table 19.3 represents the Post hoc comparison of means using LSD test on approach speed.

Table 19.3 Post hoc Comparison of Means Using LSD Test on Approach Speed

(I) zone 1	(J) zone 1	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
A	B	.13000	.16581	.441	-.2122	.4722
	C	.52000*	.16581	.004	.1778	.8622
	D	.28800	.16581	.095	-.0542	.6302
	E	.06200	.16581	.712	-.2802	.4042
	F	.32400	.16581	.062	-.0182	.6662
B	A	-.13000	.16581	.441	-.4722	.2122
	C	.39000*	.16581	.027	.0478	.7322
	D	.15800	.16581	.350	-.1842	.5002
	E	-.06800	.16581	.685	-.4102	.2742
	F	.19400	.16581	.253	-.1482	.5362
C	A	-.52000*	.16581	.004	-.8622	-.1778
	B	-.39000*	.16581	.027	-.7322	-.0478
	D	-.23200	.16581	.175	-.5742	.1102
	E	-.45800*	.16581	.011	-.8002	-.1158
	F	-.19600	.16581	.249	-.5382	.1462
D	A	-.28800	.16581	.095	-.6302	.0542
	B	-.15800	.16581	.350	-.5002	.1842
	C	.23200	.16581	.175	-.1102	.5742
	E	-.22600	.16581	.186	-.5682	.1162
	F	.03600	.16581	.830	-.3062	.3782
E	A	-.06200	.16581	.712	-.4042	.2802
	B	.06800	.16581	.685	-.2742	.4102
	C	.45800*	.16581	.011	.1158	.8002
	D	.22600	.16581	.186	-.1162	.5682
	F	.26200	.16581	.127	-.0802	.6042
F	A	-.32400	.16581	.062	-.6662	.0182
	B	-.19400	.16581	.253	-.5362	.1482
	C	.19600	.16581	.249	-.1462	.5382
	D	-.03600	.16581	.830	-.3782	.3062
	E	-.26200	.16581	.127	-.6042	.0802

*. The mean difference was significant at the 0.05 level.

Data regarding two and half step length have presented in Table 20.1 and 20.2

Table 20.1: Descriptive Analysis of Two and Half Step Length with Respect to Different Zones

Zones	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
A	5	2.9760	.22479	.10053	2.6969	3.2551
B	5	2.7300	.21401	.09571	2.4643	2.9957
C	5	2.5160	.13557	.06063	2.3477	2.6843
D	5	2.8440	.12582	.05627	2.6878	3.0002
E	5	2.9060	.34195	.15292	2.4814	3.3306
F	5	2.2620	.69579	.31117	1.3981	3.1259
Total	30	2.7057	.40493	.07393	2.5545	2.8569

Table 20.2 ANOVA Table for the Data on Two and Half Step Length

	Sum of Squares	df	Mean Square	F	P value
Between Groups	1.829	5	.366	3.000	.030
Within Groups	2.926	24	.122		
Total	4.755	29			

The result of ANOVA Table 20.2 shows that there was significant difference exists in two and half step length of layup shot in basketball concerning different zones of the two-point field goal area. ($f<0.05$) Further to identify which particular differences between pairs of means were significant, the Post hoc comparison of means using LSD test was used.

Table 20.3 represents the Post hoc comparison of means using LSD test on two and half step length.

Table 20.3 Post hoc Comparison of Means Using LSD Test on Two and Half Step Length

(I) zone 1	(J) zone 1	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
A	B	.24600	.22085	.276	-.2098	.7018
	C	.46000*	.22085	.048	.0042	.9158
	D	.13200	.22085	.556	-.3238	.5878
	E	.07000	.22085	.754	-.3858	.5258
	F	.71400*	.22085	.004	.2582	1.1698
B	A	-.24600	.22085	.276	-.7018	.2098
	C	.21400	.22085	.342	-.2418	.6698
	D	-.11400	.22085	.610	-.5698	.3418
	E	-.17600	.22085	.433	-.6318	.2798
	F	.46800*	.22085	.045	.0122	.9238
C	A	-.46000*	.22085	.048	-.9158	-.0042
	B	-.21400	.22085	.342	-.6698	.2418
	D	-.32800	.22085	.151	-.7838	.1278
	E	-.39000	.22085	.090	-.8458	.0658
	F	.25400	.22085	.261	-.2018	.7098
D	A	-.13200	.22085	.556	-.5878	.3238
	B	.11400	.22085	.610	-.3418	.5698
	C	.32800	.22085	.151	-.1278	.7838
	E	-.06200	.22085	.781	-.5178	.3938
	F	.58200*	.22085	.014	.1262	1.0378
E	A	-.07000	.22085	.754	-.5258	.3858
	B	.17600	.22085	.433	-.2798	.6318
	C	.39000	.22085	.090	-.0658	.8458
	D	.06200	.22085	.781	-.3938	.5178
	F	.64400*	.22085	.008	.1882	1.0998
F	A	-.71400*	.22085	.004	-1.1698	-.2582
	B	-.46800*	.22085	.045	-.9238	-.0122
	C	-.25400	.22085	.261	-.7098	.2018
	D	-.58200*	.22085	.014	-1.0378	-.1262
	E	-.64400*	.22085	.008	-1.0998	-.1882

*. The mean difference was significant at the 0.05 level.

Data regarding takeoff velocity have presented in Table 21.1 and 21.2

Table 21.1: Descriptive Analysis of Takeoff Velocity with Respect to Different Zones

Zones	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
A	5	3.2420	.37699	.16859	2.7739	3.7101
B	5	3.5220	.35245	.15762	3.0844	3.9596
C	5	2.6760	.33201	.14848	2.2638	3.0882
D	5	3.0020	.40040	.17906	2.5048	3.4992
E	5	3.4940	.30369	.13582	3.1169	3.8711
F	5	2.9760	.37401	.16726	2.5116	3.4404
Total	30	3.1520	.44668	.08155	2.9852	3.3188

Table 21.2 ANOVA Table for the Data on Takeoff Velocity

	Sum of Squares	df	Mean Square	F	P value
Between Groups	2.710	5	.542	4.229	.007
Within Groups	3.076	24	.128		
Total	5.786	29			

The result of ANOVA Table 21.2 shows that there was significant difference exists in takeoff velocity of layup shot in basketball concerning different zones of the two-point field goal area. (f<0.05) Further to identify which particular differences between pairs of means were significant, the Post hoc comparison of means using LSD test was used.

Table 21.3 represents the Post hoc comparison of means using LSD test on takeoff velocity.

Table 21.3 Post hoc Comparison of Means Using LSD Test on Takeoff Velocity

(I) zone 1	(J) zone 1	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
A	B	-.28000	.22642	.228	-.7473	.1873
	C	.56600*	.22642	.020	.0987	1.0333
	D	.24000	.22642	.300	-.2273	.7073
	E	-.25200	.22642	.277	-.7193	.2153
	F	.26600	.22642	.252	-.2013	.7333
B	A	.28000	.22642	.228	-.1873	.7473
	C	.84600*	.22642	.001	.3787	1.3133
	D	.52000*	.22642	.031	.0527	.9873
	E	.02800	.22642	.903	-.4393	.4953
	F	.54600*	.22642	.024	.0787	1.0133
C	A	-.56600*	.22642	.020	-1.0333	-.0987
	B	-.84600*	.22642	.001	-1.3133	-.3787
	D	-.32600	.22642	.163	-.7933	.1413
	E	-.81800*	.22642	.001	-1.2853	-.3507
	F	-.30000	.22642	.198	-.7673	.1673
D	A	-.24000	.22642	.300	-.7073	.2273
	B	-.52000*	.22642	.031	-.9873	-.0527
	C	.32600	.22642	.163	-.1413	.7933
	E	-.49200*	.22642	.040	-.9593	-.0247
	F	.02600	.22642	.910	-.4413	.4933
E	A	.25200	.22642	.277	-.2153	.7193
	B	-.02800	.22642	.903	-.4953	.4393
	C	.81800*	.22642	.001	.3507	1.2853
	D	.49200*	.22642	.040	.0247	.9593
	F	.51800*	.22642	.031	.0507	.9853
F	A	-.26600	.22642	.252	-.7333	.2013
	B	-.54600*	.22642	.024	-1.0133	-.0787
	C	.30000	.22642	.198	-.1673	.7673
	D	-.02600	.22642	.910	-.4933	.4413
	E	-.51800*	.22642	.031	-.9853	-.0507

*. The mean difference was significant at the 0.05 level.

Data regarding vertical velocity have presented in table 22.1 and 22.2

Table 22.1: Descriptive Analysis of Vertical Velocity with Respect to Different Zones

Zones	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
A	5	1.4860	.35147	.15718	1.0496	1.9224
B	5	1.7040	.32547	.14555	1.2999	2.1081
C	5	1.3340	.30705	.13732	.9527	1.7153
D	5	1.6180	.32889	.14709	1.2096	2.0264
E	5	1.8180	.38271	.17115	1.3428	2.2932
F	5	1.4600	.39122	.17496	.9742	1.9458
Total	30	1.5700	.35762	.06529	1.4365	1.7035

Table 22.2 ANOVA Table for the Data on Vertical Velocity

	Sum of Squares	df	Mean Square	F	P value
Between Groups	.783	5	.157	1.285	.303
Within Groups	2.926	24	.122		
Total	3.709	29			

The result of ANOVA Table 22.2 reveals that there was no significant difference exists in vertical velocity of layup shot in basketball concerning different zones of the two-point field goal area. (f>0.05)

Data regarding horizontal velocity have presented in table 23.1 and 23.2

Table 23.1: Descriptive Analysis of Horizontal Velocity with Respect to Different Zones

Zones	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
A	5	2.9760	.34969	.15638	2.5418	3.4102
B	5	3.0760	.29838	.13344	2.7055	3.4465
C	5	2.2980	.39060	.17468	1.8130	2.7830
D	5	2.4880	.56980	.25482	1.7805	3.1955
E	5	2.9420	.56433	.25238	2.2413	3.6427
F	5	2.5680	.31586	.14126	2.1758	2.9602
Total	30	2.7247	.48811	.08912	2.5424	2.9069

Table 23.2 ANOVA Table for the Data on Horizontal Velocity

	Sum of Squares	df	Mean Square	F	P value
Between Groups	2.482	5	.496	2.691	.046
Within Groups	4.427	24	.184		
Total	6.909	29			

The result of ANOVA Table 23.2 shows that there was significant difference exists in horizontal velocity of layup shot in basketball concerning different zones of the two-point field goal area. (f<0.05) Further to identify which particular differences between pairs of means were significant, the Post hoc comparison of means using LSD test was used.

Table 23.3 represents the Post hoc comparison of means using LSD test on horizontal velocity.

Table 23.3 Post hoc Comparison of Means Using LSD Test on Horizontal Velocity

(I) zone 1	(J) zone 1	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
A	B	-.10000	.27164	.716	-.6606	.4606
	C	.67800*	.27164	.020	.1174	1.2386
	D	.48800	.27164	.085	-.0726	1.0486
	E	.03400	.27164	.901	-.5266	.5946
	F	.40800	.27164	.146	-.1526	.9686
B	A	.10000	.27164	.716	-.4606	.6606
	C	.77800*	.27164	.009	.2174	1.3386
	D	.58800*	.27164	.041	.0274	1.1486
	E	.13400	.27164	.626	-.4266	.6946
	F	.50800	.27164	.074	-.0526	1.0686
C	A	-.67800*	.27164	.020	-1.2386	-.1174
	B	-.77800*	.27164	.009	-1.3386	-.2174
	D	-.19000	.27164	.491	-.7506	.3706
	E	-.64400*	.27164	.026	-1.2046	-.0834
	F	-.27000	.27164	.330	-.8306	.2906
D	A	-.48800	.27164	.085	-1.0486	.0726
	B	-.58800*	.27164	.041	-1.1486	-.0274
	C	.19000	.27164	.491	-.3706	.7506
	E	-.45400	.27164	.108	-1.0146	.1066
	F	-.08000	.27164	.771	-.6406	.4806
E	A	-.03400	.27164	.901	-.5946	.5266
	B	-.13400	.27164	.626	-.6946	.4266
	C	.64400*	.27164	.026	.0834	1.2046
	D	.45400	.27164	.108	-.1066	1.0146
	F	.37400	.27164	.181	-.1866	.9346
F	A	-.40800	.27164	.146	-.9686	.1526
	B	-.50800	.27164	.074	-1.0686	.0526
	C	.27000	.27164	.330	-.2906	.8306
	D	.08000	.27164	.771	-.4806	.6406
	E	-.37400	.27164	.181	-.9346	.1866

*. The mean difference was significant at the 0.05 level.

Data regarding takeoff angle have presented in table 24.1 and 24.2

Table 24.1: Descriptive Analysis of Takeoff Angle with Respect to Different Zones

Zones	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
A	5	91.200	5.8907	2.6344	83.886	98.514
B	5	90.200	6.0581	2.7092	82.678	97.722
C	5	90.600	4.5056	2.0149	85.006	96.194
D	5	92.800	5.1186	2.2891	86.444	99.156
E	5	90.800	6.9065	3.0887	82.224	99.376
F	5	93.600	4.0988	1.8330	88.511	98.689
Total	30	91.533	5.1711	.9441	89.602	93.464

Table 24.2 ANOVA Table for the Data on Takeoff Angle

	Sum of Squares	df	Mean Square	F	P value
Between Groups	45.867	5	9.173	.302	.907
Within Groups	729.600	24	30.400		
Total	775.467	29			

The result of ANOVA Table 24.2 reveals that there was no significant difference exists in takeoff angle of layup shot in basketball concerning different zones of the two-point field goal area. (f>0.05)

Data regarding height of ball release have presented in table 25.1 and 25.2

Table 25.1: Descriptive Analysis of Height of Ball Release with Respect to Different Zones

Zones	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
A	5	2.3260	.14276	.06384	2.1487	2.5033
B	5	2.3100	.10000	.04472	2.1858	2.4342
C	5	2.2360	.19882	.08892	1.9891	2.4829
D	5	2.3800	.11511	.05148	2.2371	2.5229
E	5	2.3920	.12677	.05669	2.2346	2.5494
F	5	2.2140	.09343	.04179	2.0980	2.3300
Total	30	2.3097	.13954	.02548	2.2576	2.3618

Table 25.2 ANOVA Table for the Data on Height of Ball Release

	Sum of Squares	df	Mean Square	F	P value
Between Groups	.133	5	.027	1.477	.234
Within Groups	.432	24	.018		
Total	.565	29			

The result of ANOVA Table 25.2 reveals that there was no significant difference exists in height of ball release of layup shot in basketball concerning different zones of the two-point field goal area. (f>0.05)

Data regarding angle of ball release have presented in table 26.1 and 26.2

Table 26.1: Descriptive Analysis of Angle of Ball Release with Respect to Different Zones

					95% Confidence Interval for Mean	
Zones	N	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound
A	5	61.400	9.3434	4.1785	49.799	73.001
B	5	58.400	4.2778	1.9131	53.088	63.712
C	5	59.600	3.4351	1.5362	55.335	63.865
D	5	59.800	8.4676	3.7868	49.286	70.314
E	5	56.400	8.0808	3.6139	46.366	66.434
F	5	62.600	8.9610	4.0075	51.473	73.727
Total	30	59.700	7.0913	1.2947	57.052	62.348

Table 26.2 ANOVA Table for the Data on Angle of Ball Release

	Sum of Squares	df	Mean Square	F	P value
Between Groups	119.500	5	23.900	.428	.824
Within Groups	1338.800	24	55.783		
Total	1458.300	29			

The result of ANOVA Table 26.2 reveals that there was no significant difference exists in angle of ball release of layup shot in basketball concerning different zones of the two-point field goal area. (f>0.05)

Data regarding speed of ball release have presented in table 27.1 and 27.2

Table 27.1: Descriptive Analysis of Speed of Ball Release with Respect to Different Zones

Zones	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
A	5	4.8260	.38109	.17043	4.3528	5.2992
B	5	4.8480	.58913	.26347	4.1165	5.5795
C	5	4.5560	.47732	.21346	3.9633	5.1487
D	5	4.4660	.32292	.14442	4.0650	4.8670
E	5	5.0920	.52637	.23540	4.4384	5.7456
F	5	4.9560	.49176	.21992	4.3454	5.5666
Total	30	4.7907	.48384	.08834	4.6100	4.9713

Table 27.2 ANOVA Table for the Data on Speed of Ball Release

	Sum of Squares	df	Mean Square	F	P value
Between Groups	1.416	5	.283	1.265	.311
Within Groups	5.373	24	.224		
Total	6.789	29			

The result of ANOVA Table 27.2 reveals that there was no significant difference exists in speed of ball release of layup shot in basketball concerning different zones of the two-point field goal area. (f>0.05)

Data regarding angular velocity of ankle have presented in table 28.1 and 28.2

Table 28.1: Descriptive Analysis of Angular Velocity of Ankle with Respect to Different Zones

Zones	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
A	5	9.1180	1.39935	.62581	7.3805	10.8555
B	5	9.5100	1.51803	.67888	7.6251	11.3949
C	5	8.7260	2.07476	.92786	6.1498	11.3022
D	5	7.8960	1.11818	.50007	6.5076	9.2844
E	5	8.7720	1.50684	.67388	6.9010	10.6430
F	5	9.2040	.94442	.42236	8.0313	10.3767
Total	30	8.8710	1.43513	.26202	8.3351	9.4069

Table 28.2 ANOVA Table for the Data on Angular Velocity of Ankle

	Sum of Squares	df	Mean Square	F	P value
Between Groups	7.808	5	1.562	.722	.614
Within Groups	51.920	24	2.163		
Total	59.728	29			

The result of ANOVA Table 28.2 reveals that there was no significant difference exists in angular velocity of ankle of layup shot in basketball concerning different zones of the two-point field goal area. (f>0.05)

Data regarding angular velocity of knee have presented in table 29.1 and 29.2

Table 29.1: Descriptive Analysis of Angular Velocity of Knee with Respect to Different Zones

					95% Confidence Interval for Mean	
Zones	N	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound
A	5	6.4580	1.70043	.76046	4.3466	8.5694
B	5	6.0200	1.60642	.71841	4.0254	8.0146
C	5	4.8880	2.54378	1.13761	1.7295	8.0465
D	5	4.8860	1.63787	.73248	2.8523	6.9197
E	5	4.0580	1.95814	.87571	1.6266	6.4894
F	5	6.8920	2.23362	.99891	4.1186	9.6654
Total	30	5.5337	2.06402	.37684	4.7629	6.3044

Table 29.2 ANOVA Table for the Data on Angular Velocity of Knee

	Sum of Squares	df	Mean Square	F	P value
Between Groups	29.750	5	5.950	1.522	.220
Within Groups	93.796	24	3.908		
Total	123.545	29			

The result of ANOVA Table 29.2 reveals that there was no significant difference exists in angular velocity of knee of layup shot in basketball concerning different zones of the two-point field goal area. (f>0.05)

Data regarding angular velocity of shoulder have presented in table 30.1 and 30.2

Table 30.1: Descriptive Analysis of Angular Velocity of Shoulder with Respect to Different Zones

Zones	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
A	5	8.1160	1.62168	.72524	6.1024	10.1296
B	5	7.9840	1.62169	.72524	5.9704	9.9976
C	5	6.7620	1.57570	.70467	4.8055	8.7185
D	5	6.0200	1.83016	.81847	3.7476	8.2924
E	5	6.6300	1.57808	.70574	4.6705	8.5895
F	5	7.4640	2.28031	1.01979	4.6326	10.2954
Total	30	7.1627	1.78354	.32563	6.4967	7.8287

Table 30.2 ANOVA Table for the Data on Angular Velocity of Shoulder

	Sum of Squares	df	Mean Square	F	P value
Between Groups	17.121	5	3.424	1.094	.389
Within Groups	75.129	24	3.130		
Total	92.250	29			

The result of ANOVA Table 30.2 reveals that there was no significant difference exists in angular velocity of shoulder of layup shot in basketball concerning different zones of the two-point field goal area. (f>0.05)

Data regarding angular velocity of elbow have presented in table 31.1 and 31.2

Table 31.1: Descriptive Analysis of Angular Velocity of Elbow with Respect to Different Zones

Zones	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
A	5	10.6020	1.77569	.79411	8.3972	12.8068
B	5	9.5100	4.52863	2.02527	3.8870	15.1330
C	5	7.3300	2.41389	1.07952	4.3328	10.3272
D	5	9.0320	3.89762	1.74307	4.1925	13.8715
E	5	8.8140	2.35186	1.05178	5.8938	11.7342
F	5	9.0760	3.82388	1.71009	4.3280	13.8240
Total	30	9.0607	3.14865	.57486	7.8849	10.2364

Table 31.2 ANOVA Table for the Data on Angular Velocity of Elbow

	Sum of Squares	df	Mean Square	F	P value
Between Groups	28.174	5	5.635	.521	.758
Within Groups	259.333	24	10.806		
Total	287.506	29			

The result of ANOVA Table 31.2 reveals that there was no significant difference exists in angular velocity of elbow of layup shot in basketball concerning different zones of the two-point field goal area. (f>0.05)

Data regarding angular velocity of wrist have presented in table 32.1 and 32.2

Table 32.1: Descriptive Analysis of Angular Velocity of Wrist with Respect to Different Zones

Zones	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
A	5	6.5000	4.38328	1.96026	1.0574	11.9426
B	5	7.0700	3.83808	1.71644	2.3044	11.8356
C	5	6.5420	2.18779	.97841	3.8255	9.2585
D	5	7.4160	3.49125	1.56133	3.0810	11.7510
E	5	6.5000	3.30832	1.47953	2.3922	10.6078
F	5	3.1840	1.19291	.53348	1.7028	4.6652
Total	30	6.2020	3.27631	.59817	4.9786	7.4254

Table 32.2 ANOVA Table for the Data on Angular Velocity of Wrist

	Sum of Squares	df	Mean Square	F	P value
Between Groups	58.144	5	11.629	1.102	.385
Within Groups	253.149	24	10.548		
Total	311.293	29			

The result of ANOVA Table 32.2 reveals that there was no significant difference exists in angular velocity of wrist of layup shot in basketball concerning different zones of the two-point field goal area. (f>0.05)

Data regarding duration of total flight have presented in table 33.1 and 33.2

Table 33.1: Descriptive Analysis of Duration of Total Flight with Respect to Different Zones

Zones	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
A	5	.3920	.09121	.04079	.2787	.5053
B	5	.3920	.09121	.04079	.2787	.5053
C	5	.3840	.10040	.04490	.2593	.5087
D	5	.4080	.09550	.04271	.2894	.5266
E	5	.4000	.10198	.04561	.2734	.5266
F	5	.4080	.07155	.03200	.3192	.4968
Total	30	.3973	.08465	.01545	.3657	.4289

Table 33.2 ANOVA Table for the Data on Duration of Total Flight

	Sum of Squares	df	Mean Square	F	P value
Between Groups	.002	5	.000	.055	.998
Within Groups	.205	24	.009		
Total	.208	29			

The result of ANOVA Table 33.2 reveals that there was no significant difference exists in duration of total flight of layup shot in basketball concerning different zones of the two-point field goal area. ($f>0.05$)

Data regarding lowering of C.G have presented in table 34.1 and 34.2

Table 34.1: Descriptive Analysis of Lowering of C.G with Respect to Different Zones

Zones	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
A	5	.1940	.04219	.01887	.1416	.2464
B	5	.2440	.06189	.02768	.1672	.3208
C	5	.1960	.04722	.02112	.1374	.2546
D	5	.2540	.05030	.02249	.1915	.3165
E	5	.1780	.05263	.02354	.1127	.2433
F	5	.1920	.05357	.02396	.1255	.2585
Total	30	.2097	.05524	.01009	.1890	.2303

Table 34.2 ANOVA Table for the Data on Lowering of C.G

	Sum of Squares	df	Mean Square	F	P value
Between Groups	.024	5	.005	1.833	.144
Within Groups	.064	24	.003		
Total	.088	29			

The result of ANOVA Table 33.2 reveals that there was no significant difference exists in lowering of C.G of layup shot in basketball concerning different zones of the two-point field goal area. (f>0.05)

4.3 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 significant difference 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.

4.4 Discussions

Approach Speed for layup shot in basketball with respect to different zones in the two point field goal area for male and female players has shown in figure 1 and 2 respectively

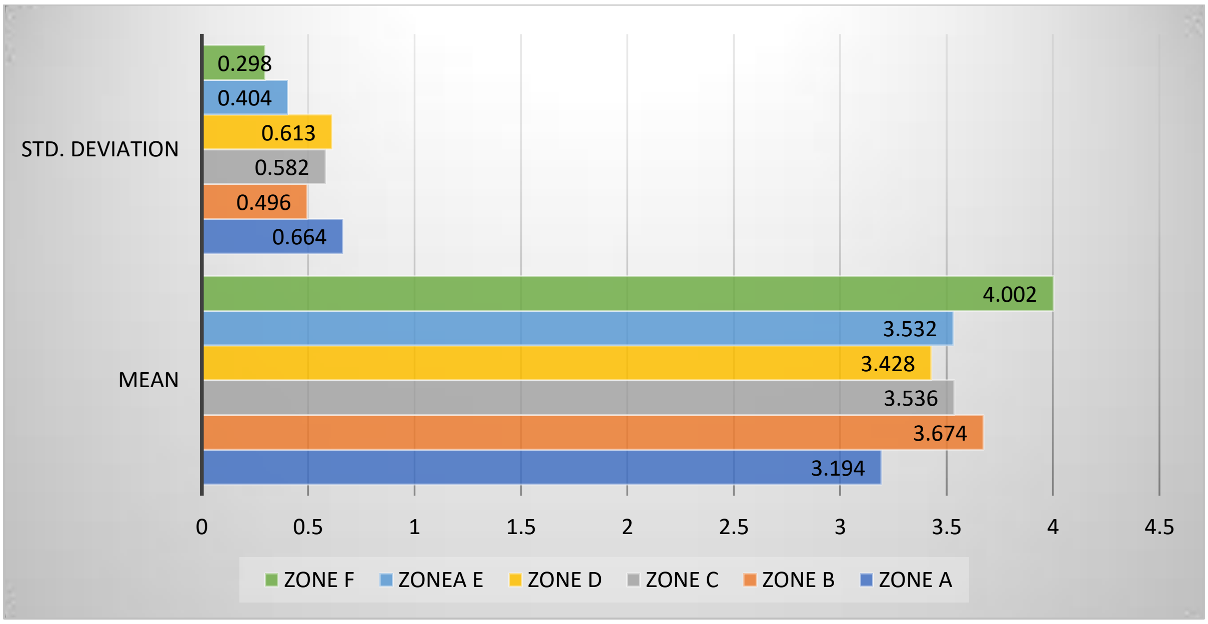


Figure 1: Approach Speed (m/s) for Layup Shot in Basketball with Respect to Different Zones for Male Basketball Players

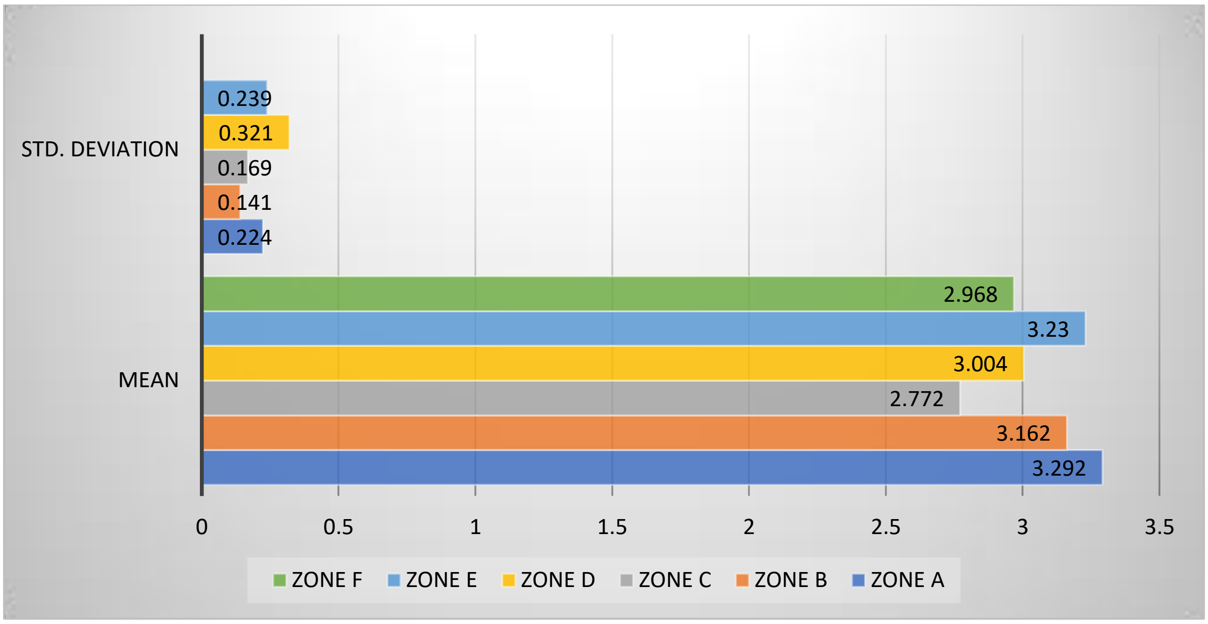


Figure 2: Approach Speed (m/s) for Layup Shot in Basketball with Respect to Different Zones for Female Basketball Players

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.

Two and half step length for layup shot in basketball with respect to different zones in the two point field goal area for male and female players has shown in figure 3 and 4 respectively

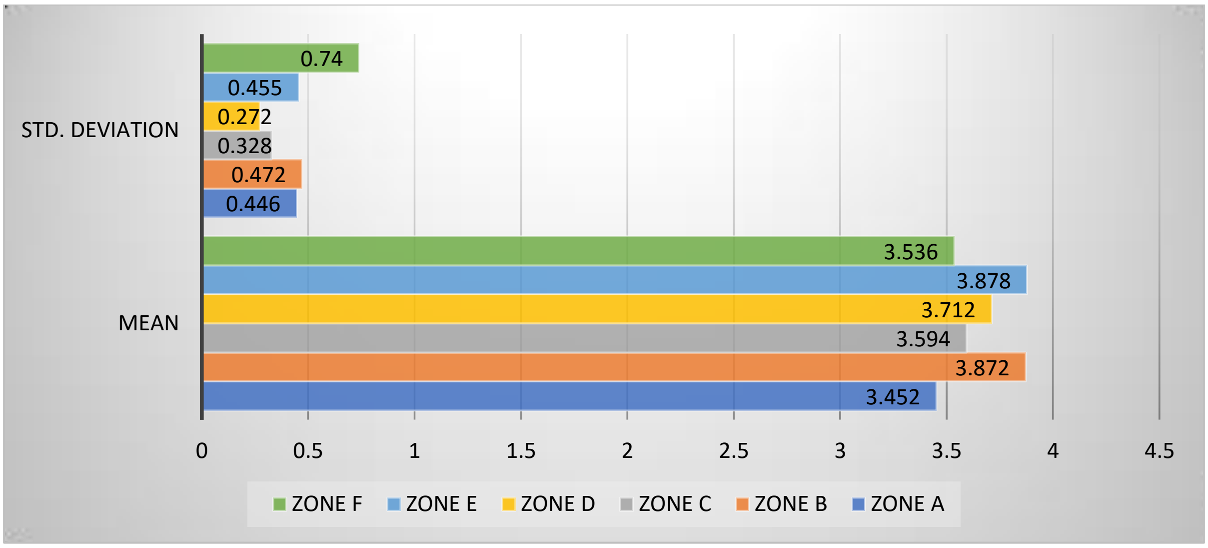


Figure 3: Two and half step length (mt.) for Layup Shot in Basketball with Respect to Different Zones for Male Basketball Players

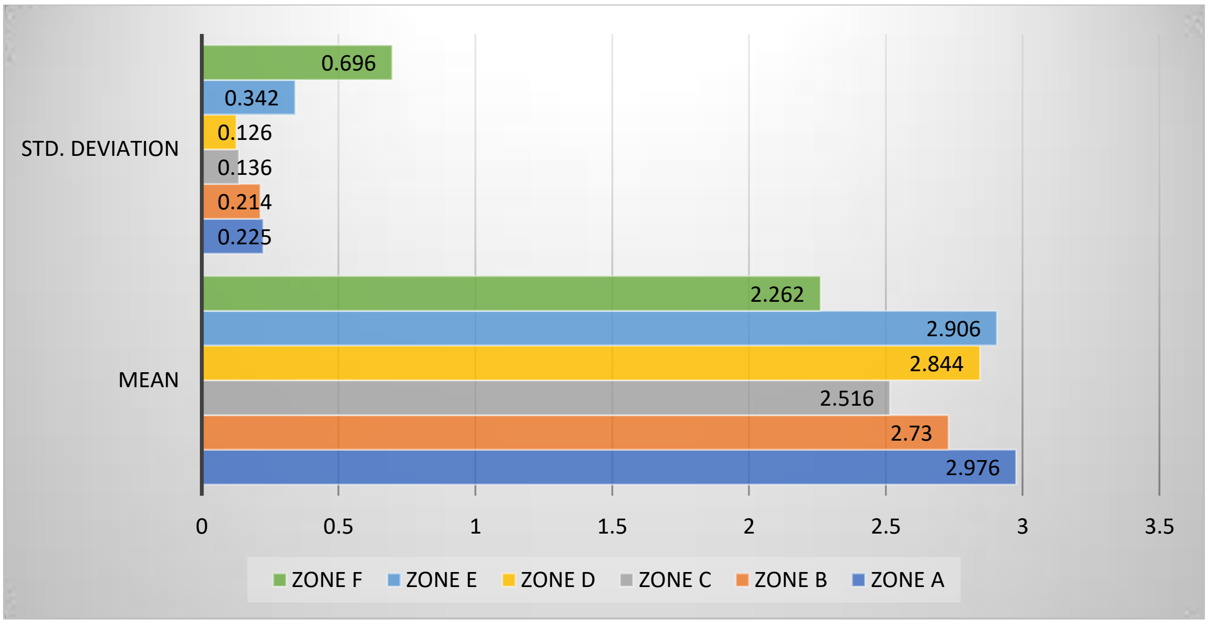


Figure 4: Two and half step length (m/s) for Layup Shot in Basketball with Respect to Different Zones for Female Basketball Players

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.

Takeoff velocity for layup shot in basketball with respect to different zones in the two point field goal area for male and female players has shown in figure 5 and 6 respectively

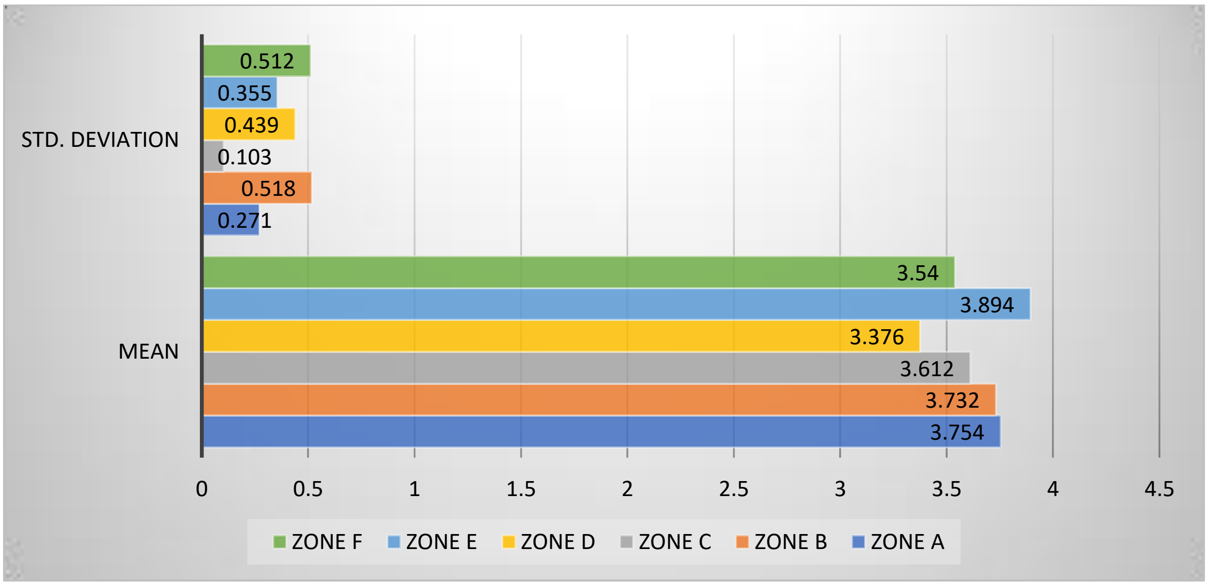


Figure 5: Takeoff velocity for Layup Shot in Basketball with Respect to Different Zones for Male Basketball Players

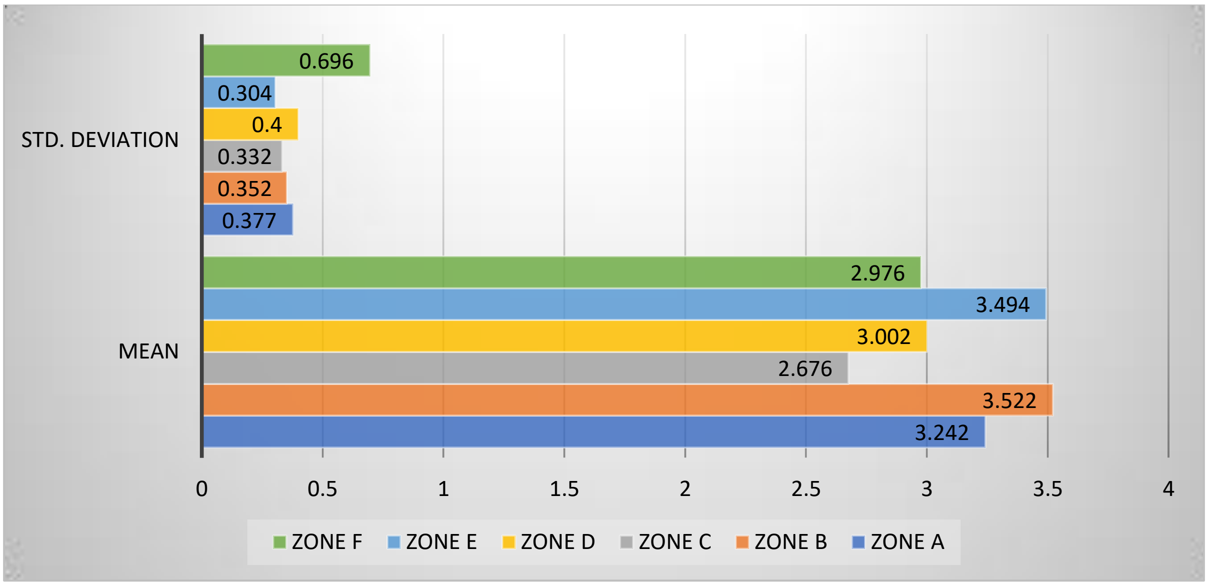


Figure 6: Takeoff velocity for Layup Shot in Basketball with Respect to Different Zones for Female Basketball Players

The vertical and horizontal component of takeoff velocity for layup shot in basketball with respect to different zones in the two point field goal area for male and female players has shown in figure 7,8,9 and 10 respectively

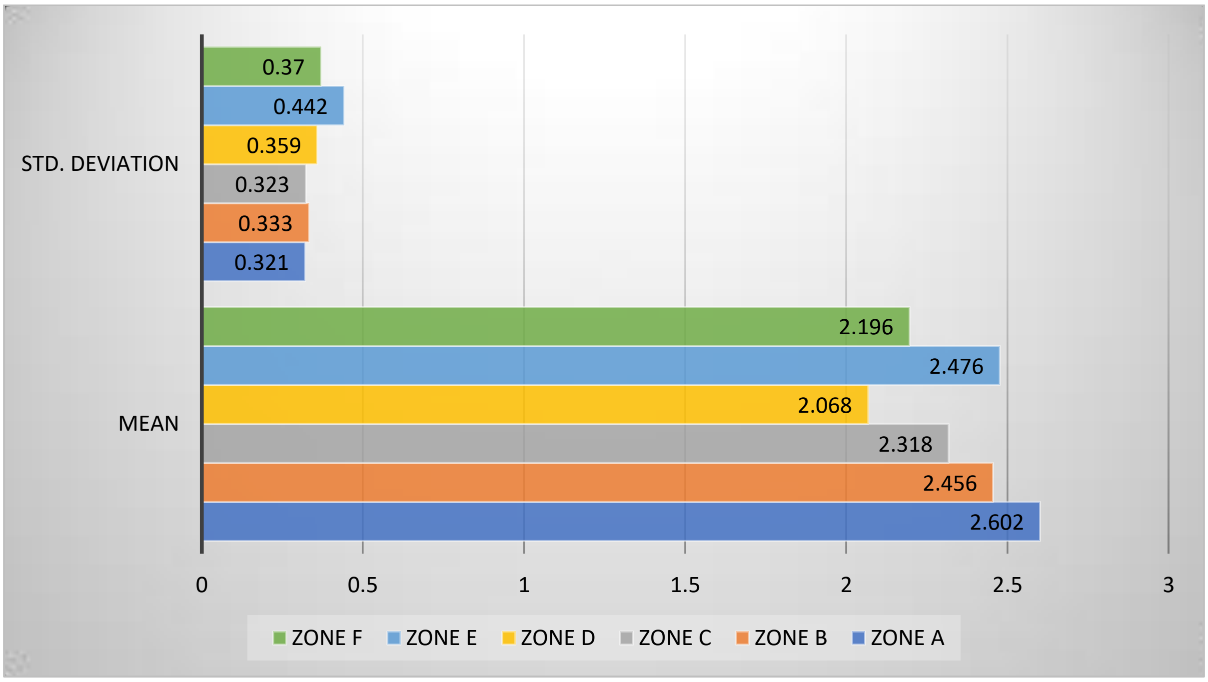


Figure 7: Vertical velocity for Layup Shot in Basketball with Respect to Different Zones for Male Basketball Players

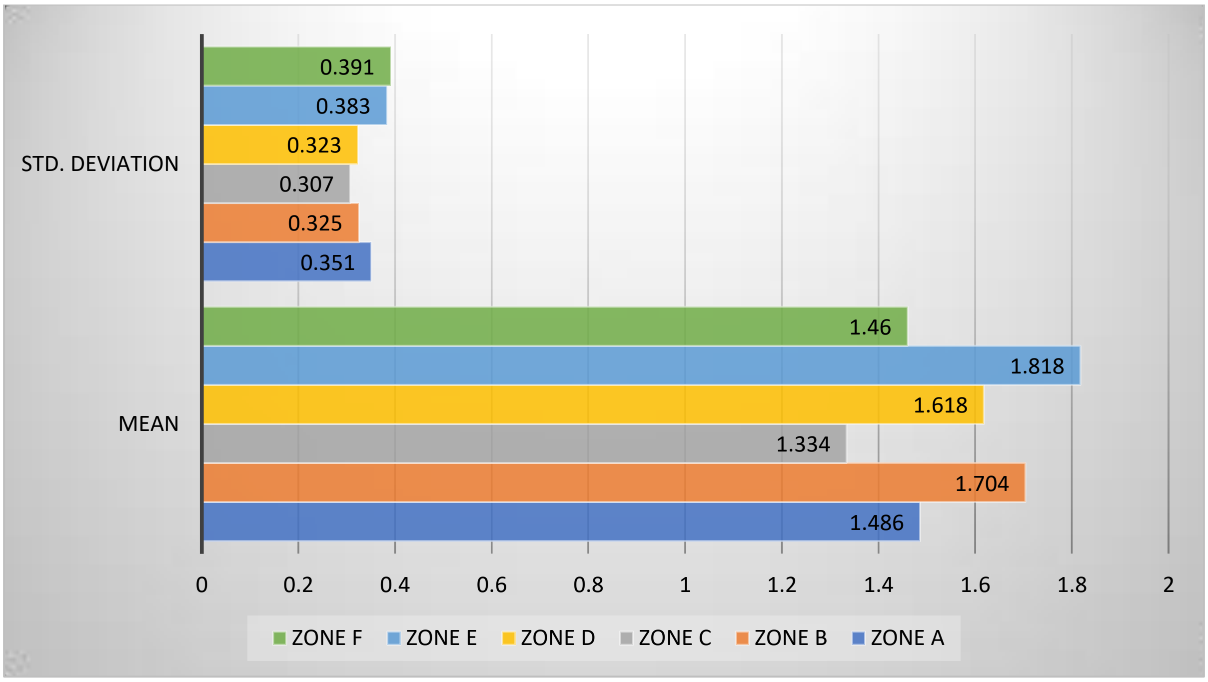


Figure 8: Vertical velocity for Layup Shot in Basketball with Respect to Different Zones for Female Basketball Players

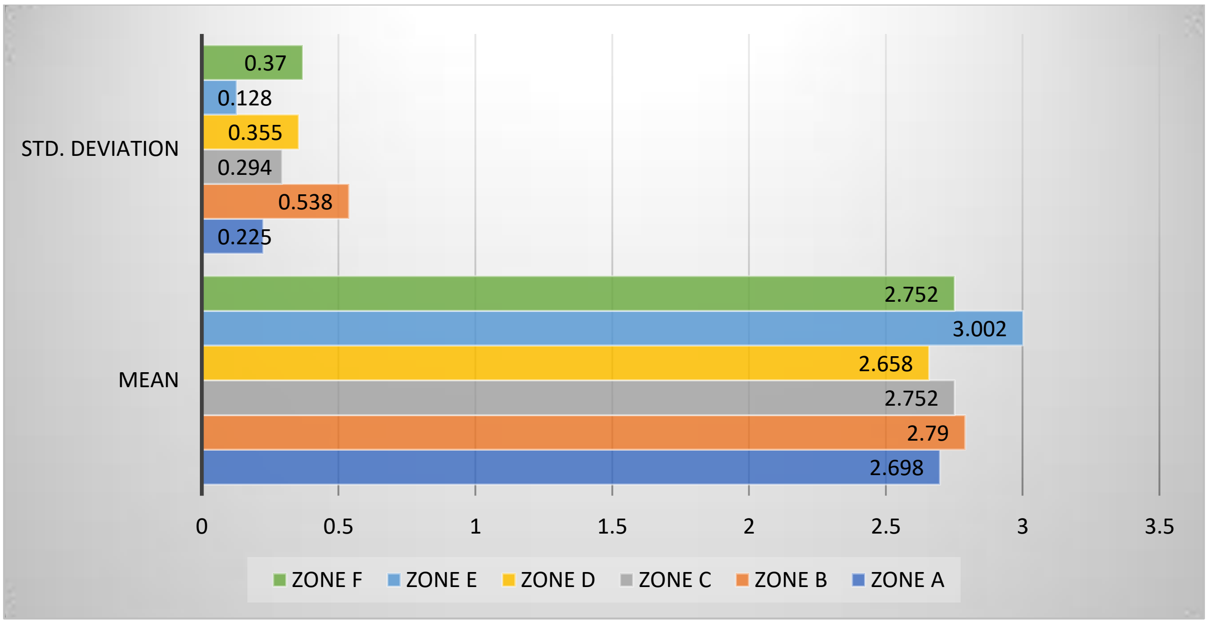


Figure 9: Horizontal velocity for Layup Shot in Basketball with Respect to Different Zones for Male Basketball Players

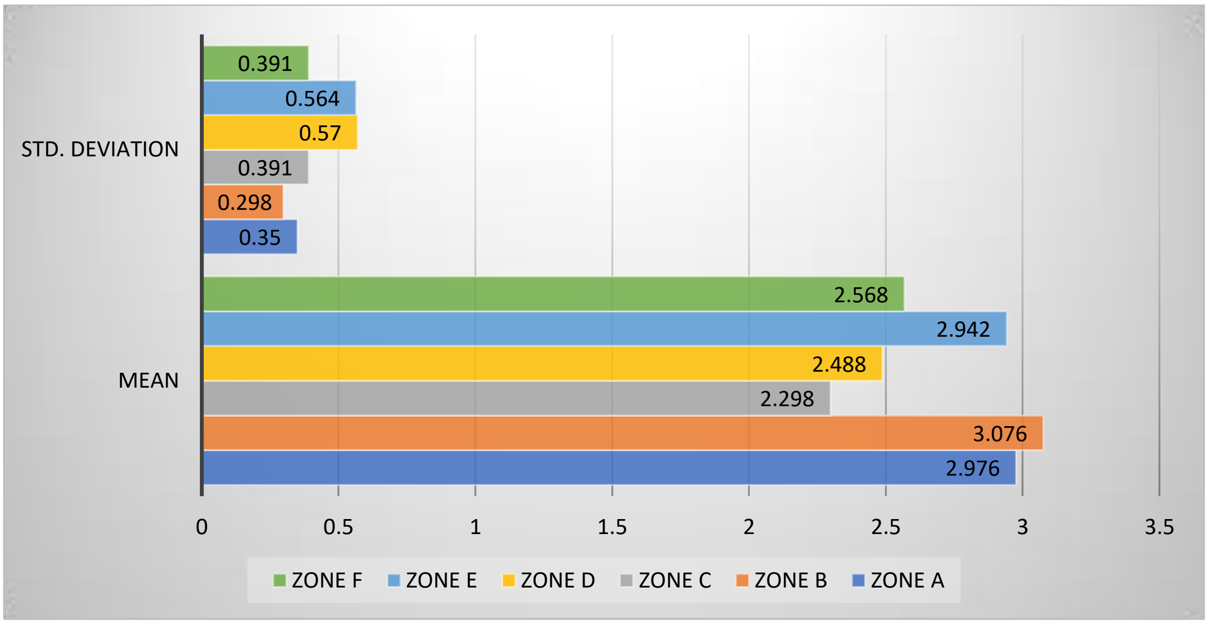


Figure 10: Horizontal velocity for Layup Shot in Basketball with Respect to Different Zones for Female Basketball Players

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 etal. (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.

Takeoff angle for layup shot in basketball with respect to different zones in the two point field goal area for male and female players has shown in figure 11 and 12 respectively

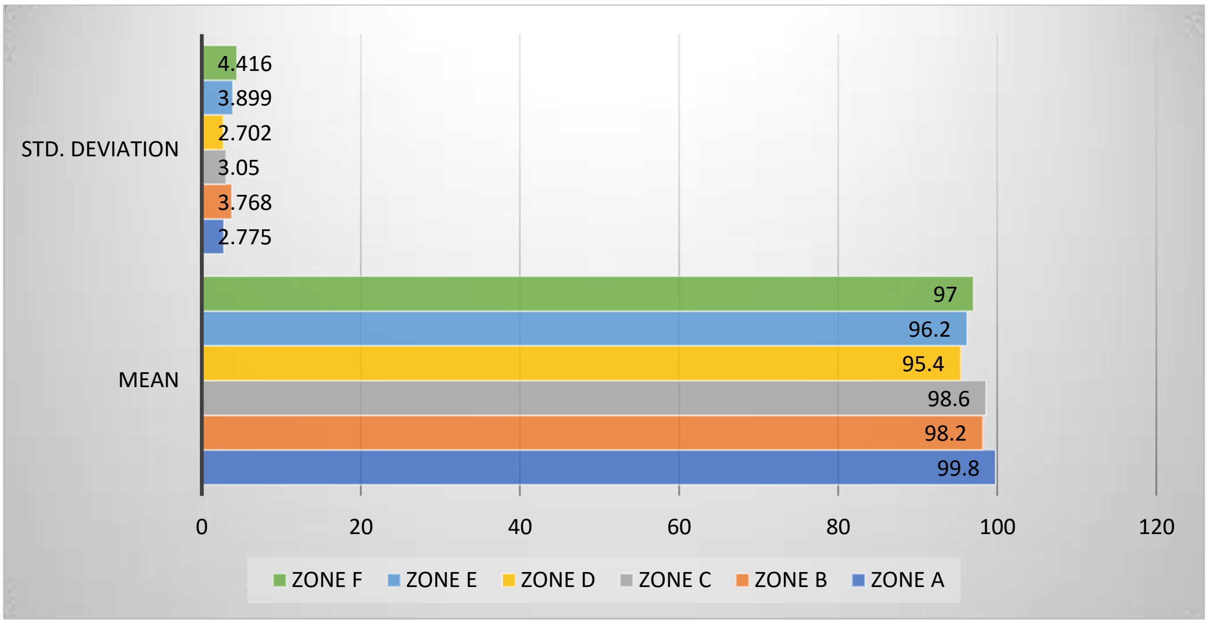


Figure 11: Takeoff angle for Layup Shot in Basketball with Respect to Different Zones for Male Basketball players

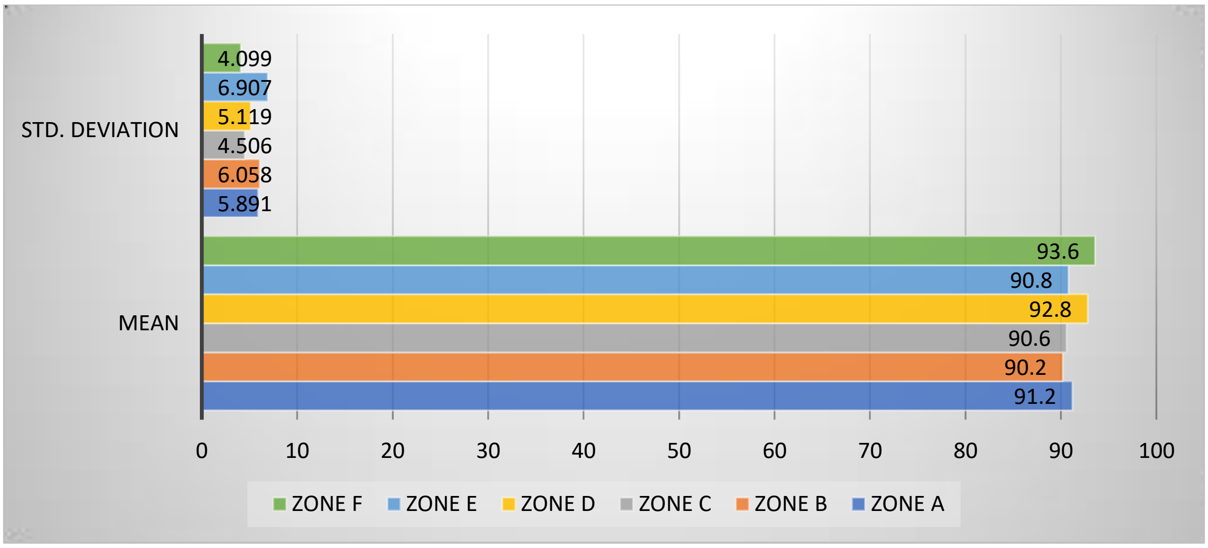


Figure 12: Takeoff angle for Layup Shot in Basketball with Respect to Different Zones for Female Basketball Players

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.

Height of ball release for layup shot in basketball with respect to different zones in the two point field goal area for male and female players has shown in figure 13 and 14 respectively

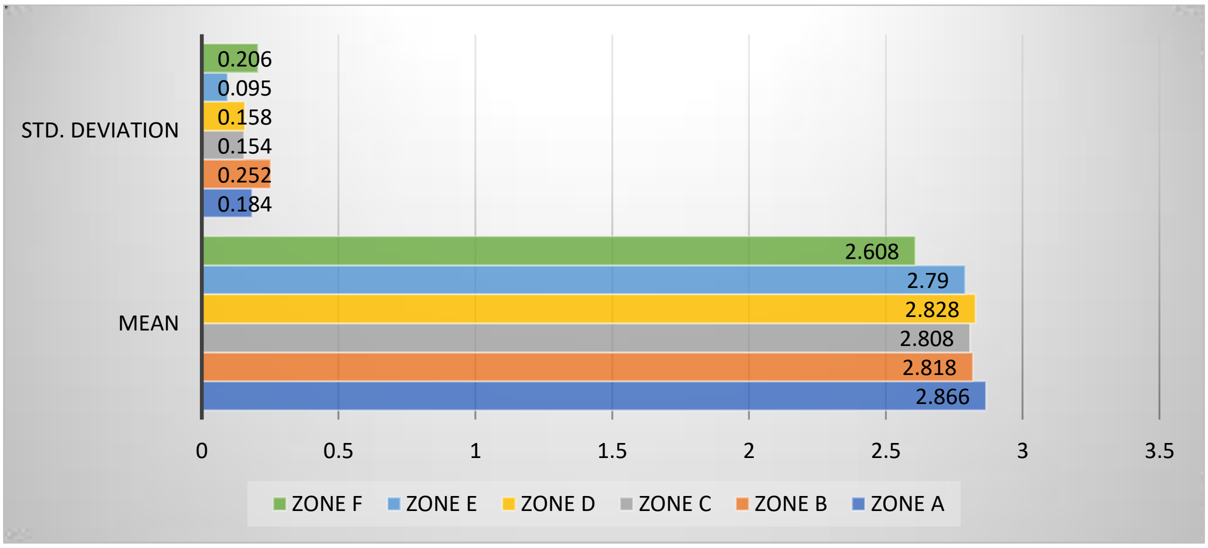


Figure 13: Height of ball release for Layup Shot in Basketball with Respect to Different Zones for Male Basketball Players

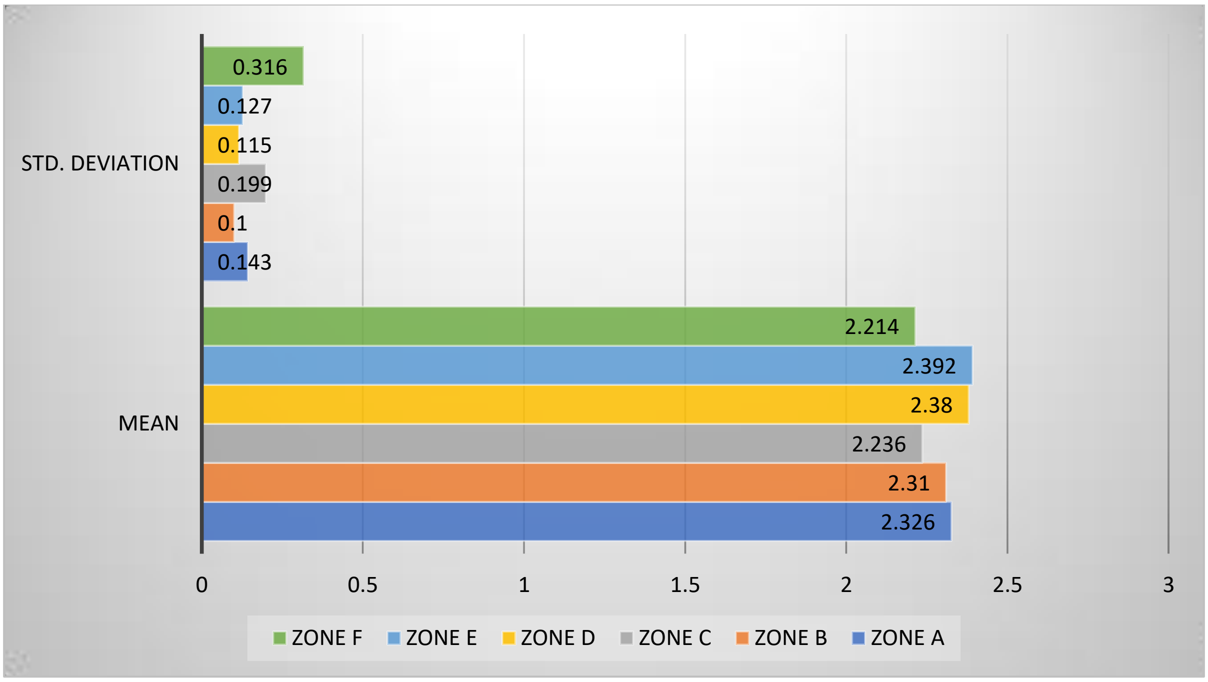


Figure 14: Height of ball release for layup shot in Basketball with Respect to Different Zones for Female Basketball Players

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.

Angle of ball release for layup shot in basketball with respect to different zones in the two point field goal area for male and female players has shown in figure 15 and 16 respectively

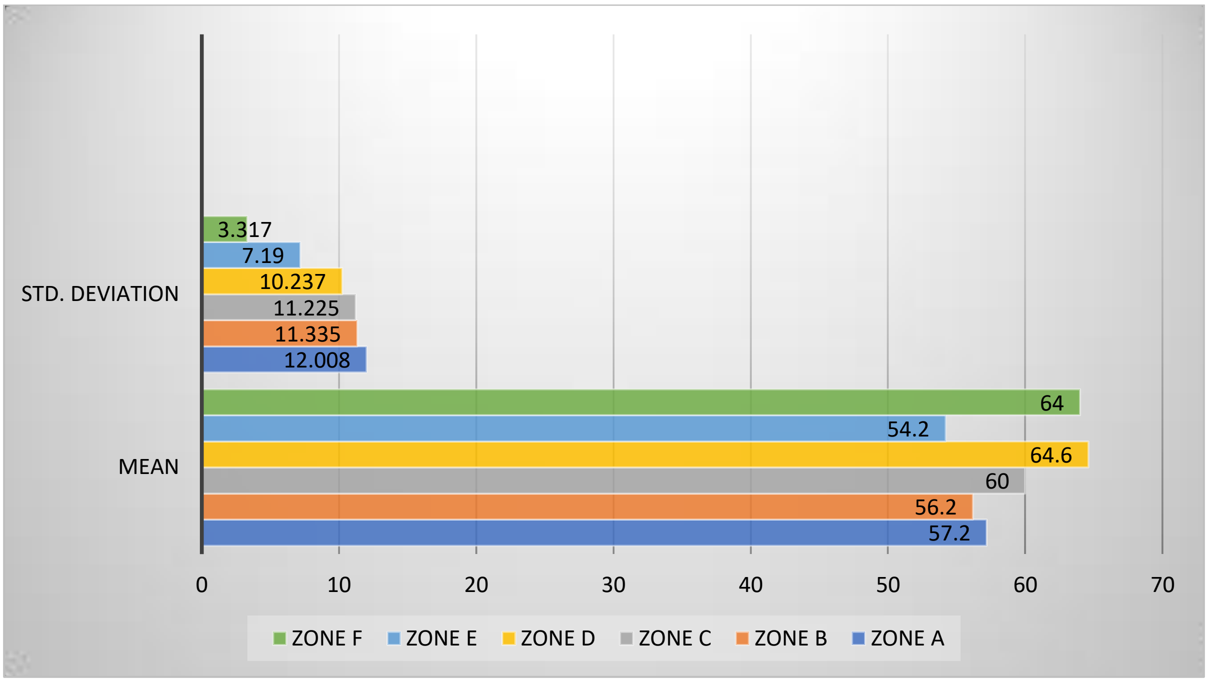


Figure 15: Angle of ball release for Layup Shot in Basketball with Respect to Different Zones for Male Basketball Players

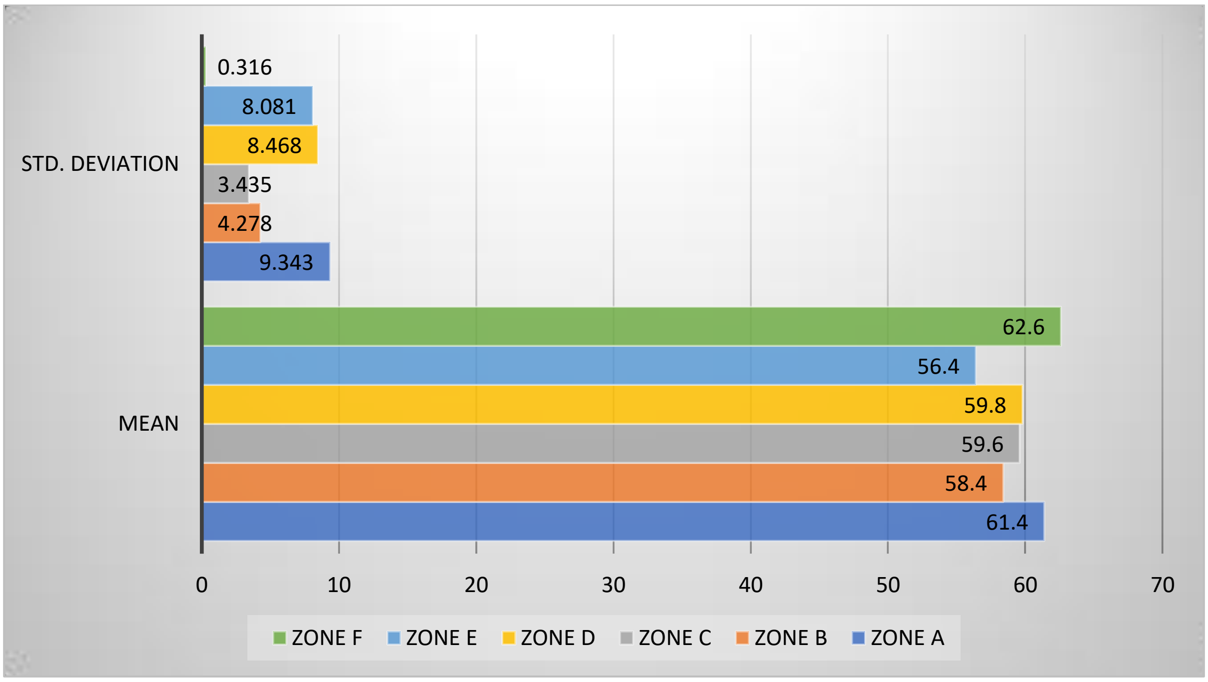


Figure 16: Angle of ball release for Layup Shot in Basketball with Respect to Different Zones for Female Basketball Players

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 etal.** 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.

Speed of ball release for layup shot in basketball with respect to different zones in the two point field goal area for male and female players has shown in figure 17 and 18 respectively

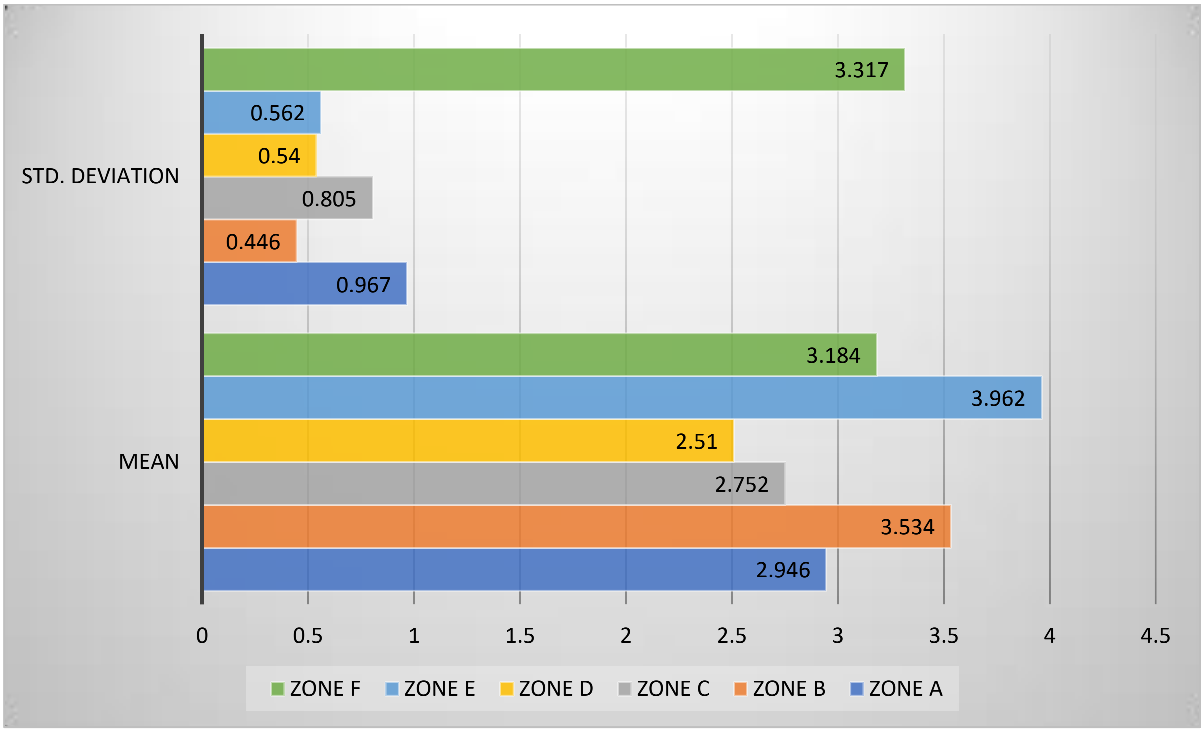


Figure 17: Speed of ball release for Layup Shot in Basketball with Respect to Different Zones for Male Basketball Players

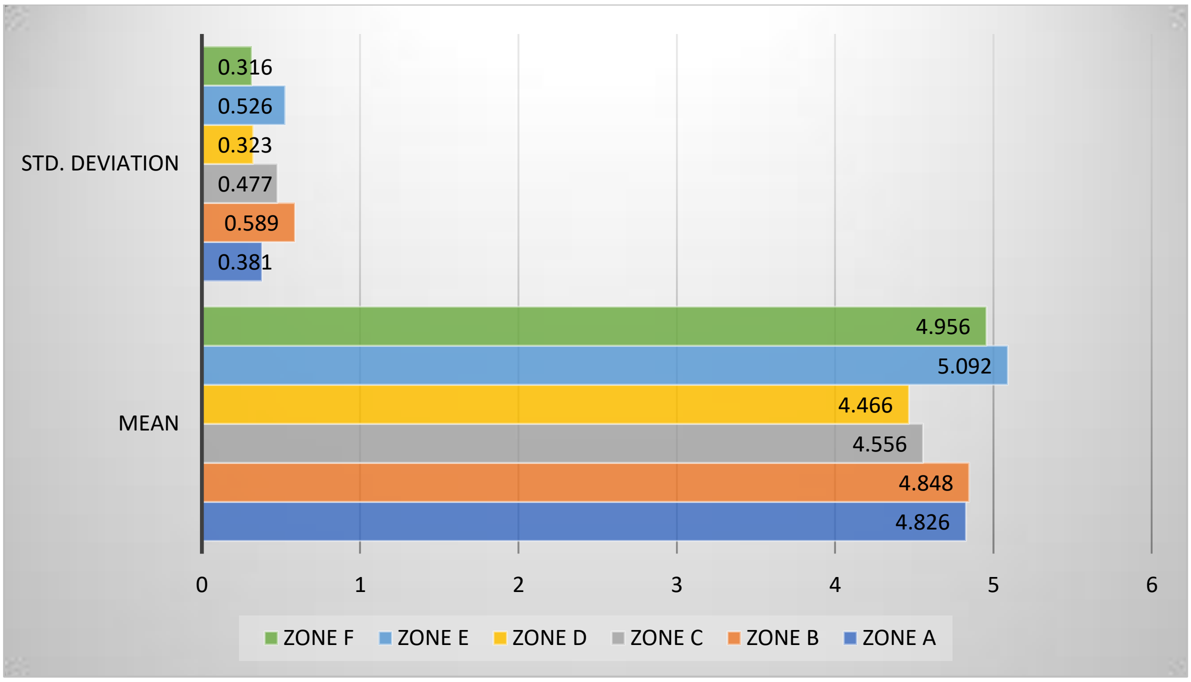


Figure 18: Speed of ball release for Layup Shot in Basketball with Respect to Different Zones for Female Basketball Players

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 etal. (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.

Angular velocity of various segment for layup shot in basketball with respect to different zones in the two point field goal area for male and female players has shown in figure 19 to 28 respectively

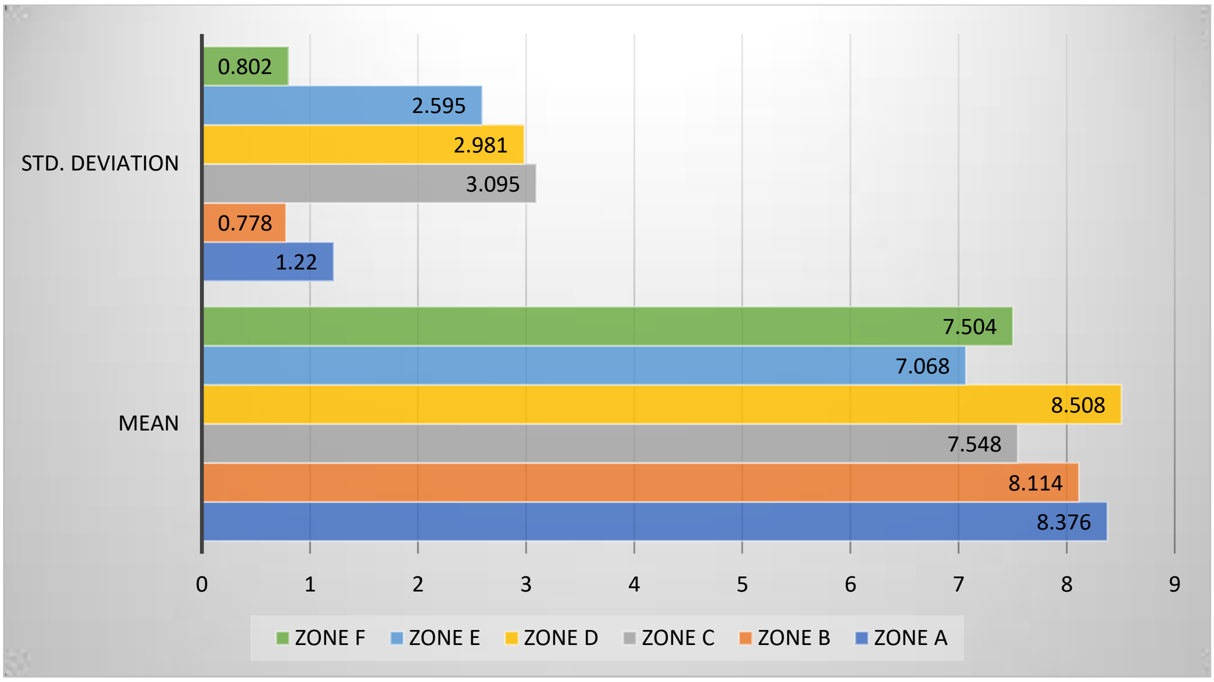


Figure 19: Angular Velocity of Ankle for Layup Shot in Basketball with Respect to Different Zones for Male Basketball Players

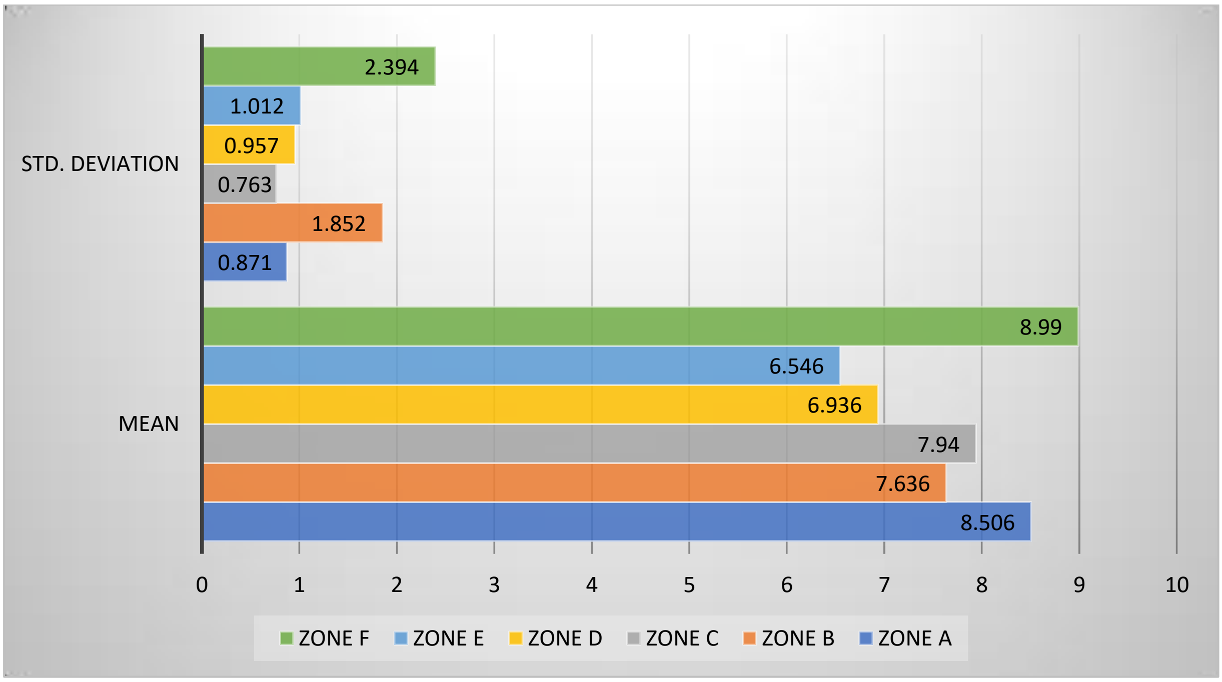


Figure 20: Angular Velocity of knee for Layup Shot in Basketball with Respect to Different Zones for Male Basketball Players

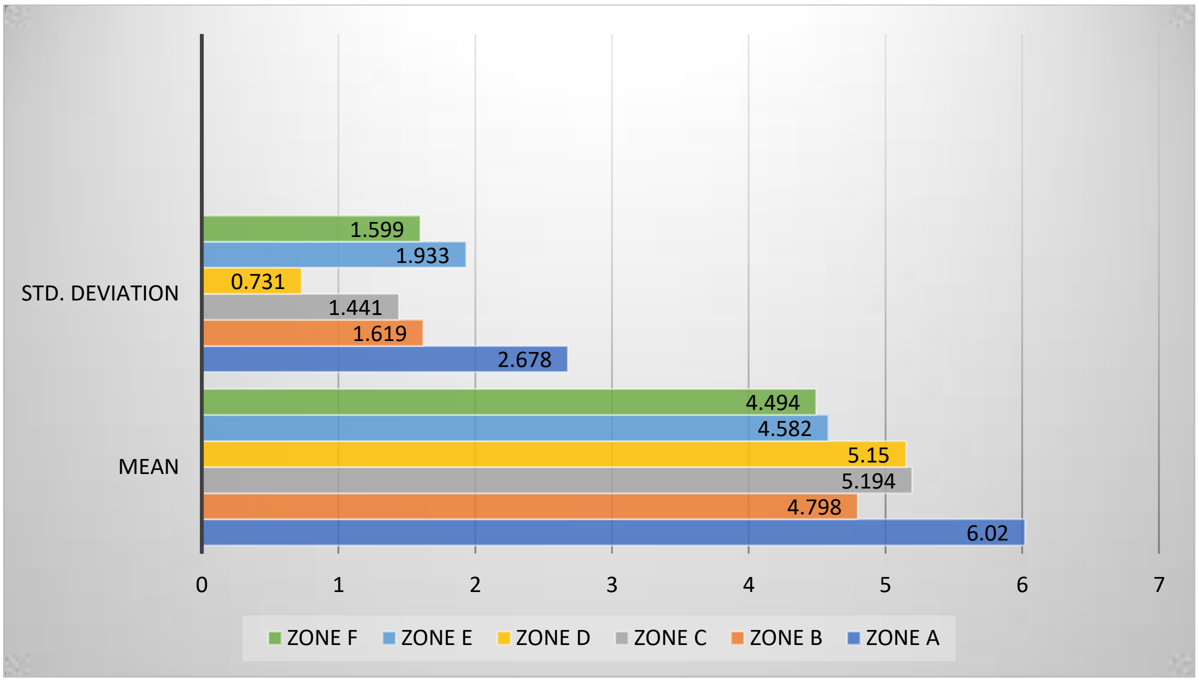


Figure 21: Angular Velocity of shoulder for Layup Shot in Basketball with Respect to Different Zones for Male Basketball Players

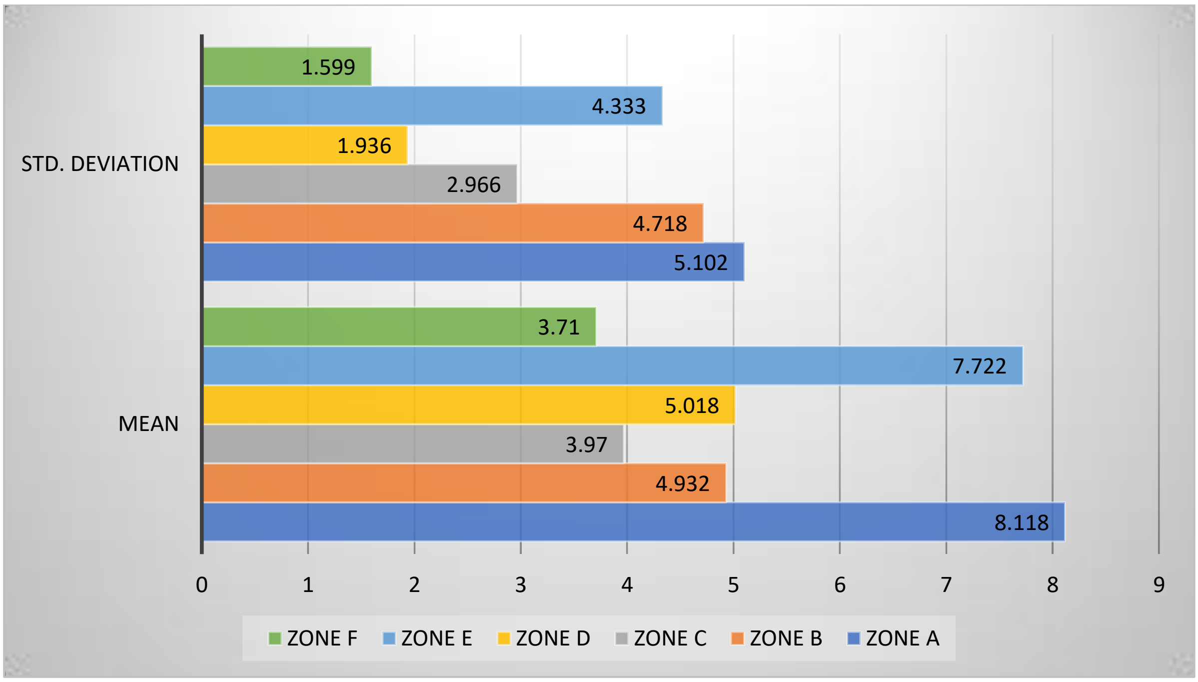


Figure 22: Angular Velocity of elbow for Layup Shot in Basketball with Respect to Different Zones for Male Basketball Players

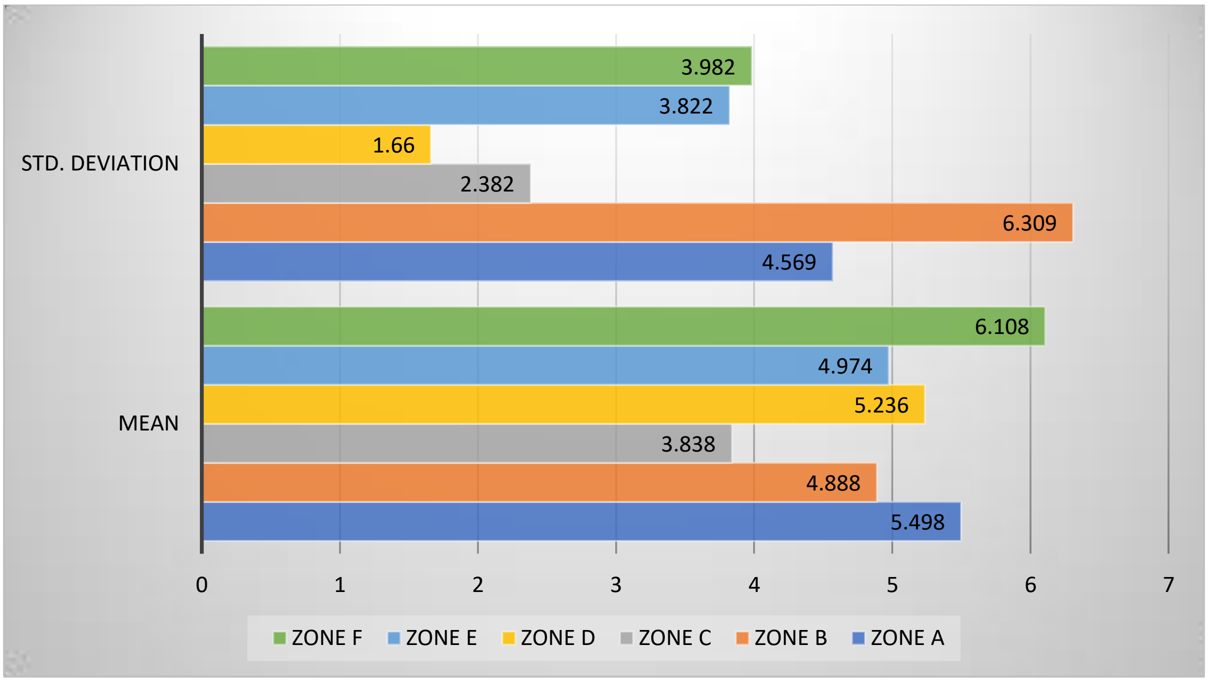


Figure 23: Angular Velocity of wrist for Layup Shot in Basketball with Respect to Different Zones for Male Basketball Players

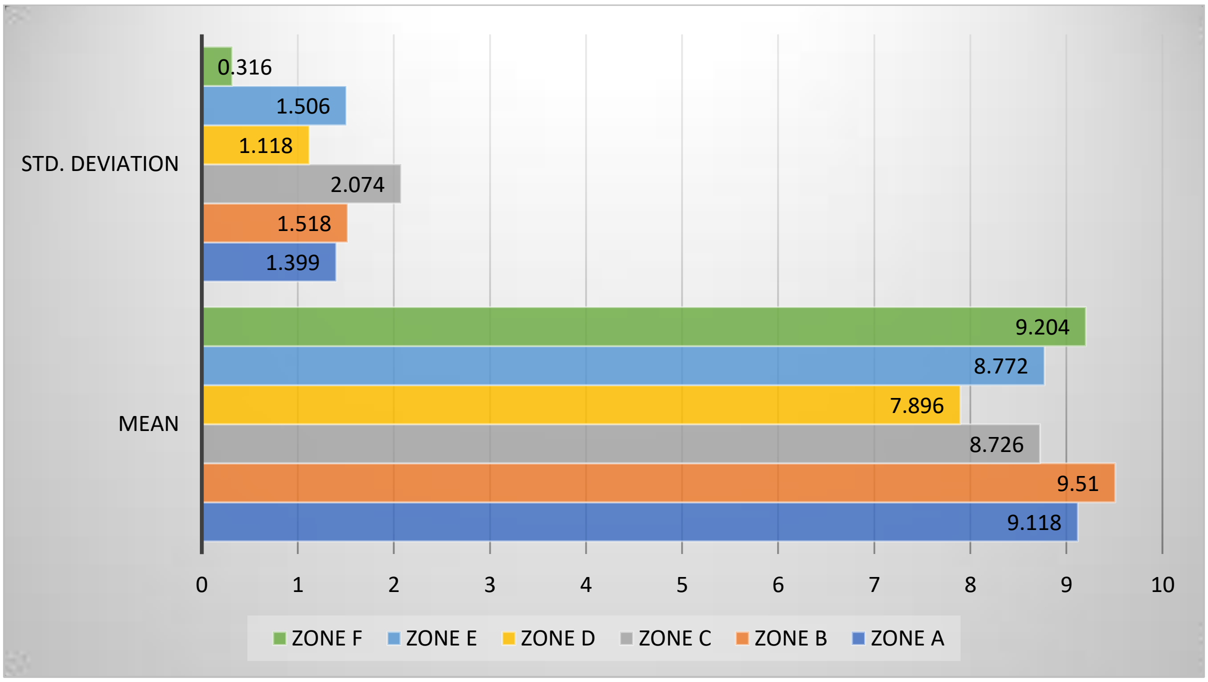


Figure 24: Angular Velocity of Ankle for Layup Shot in Basketball with Respect to Different Zones for Female Basketball Players

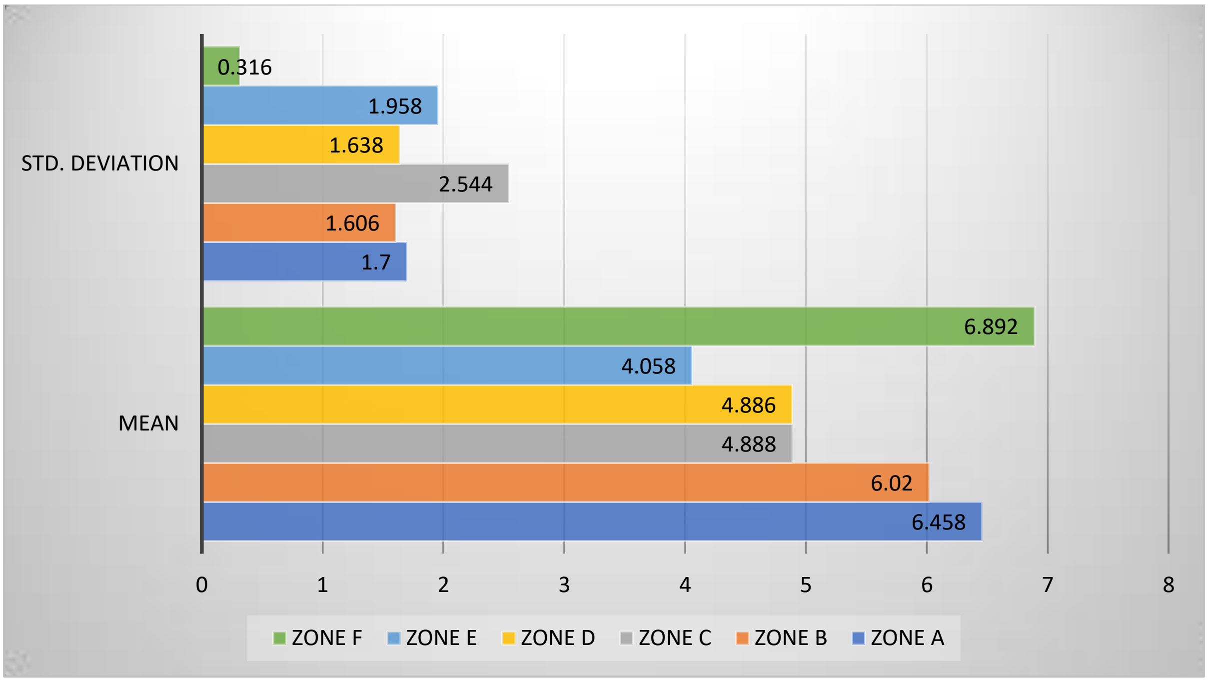


Figure 25: Angular Velocity of knee for Layup Shot in Basketball with Respect to Different Zones for Female Basketball Players

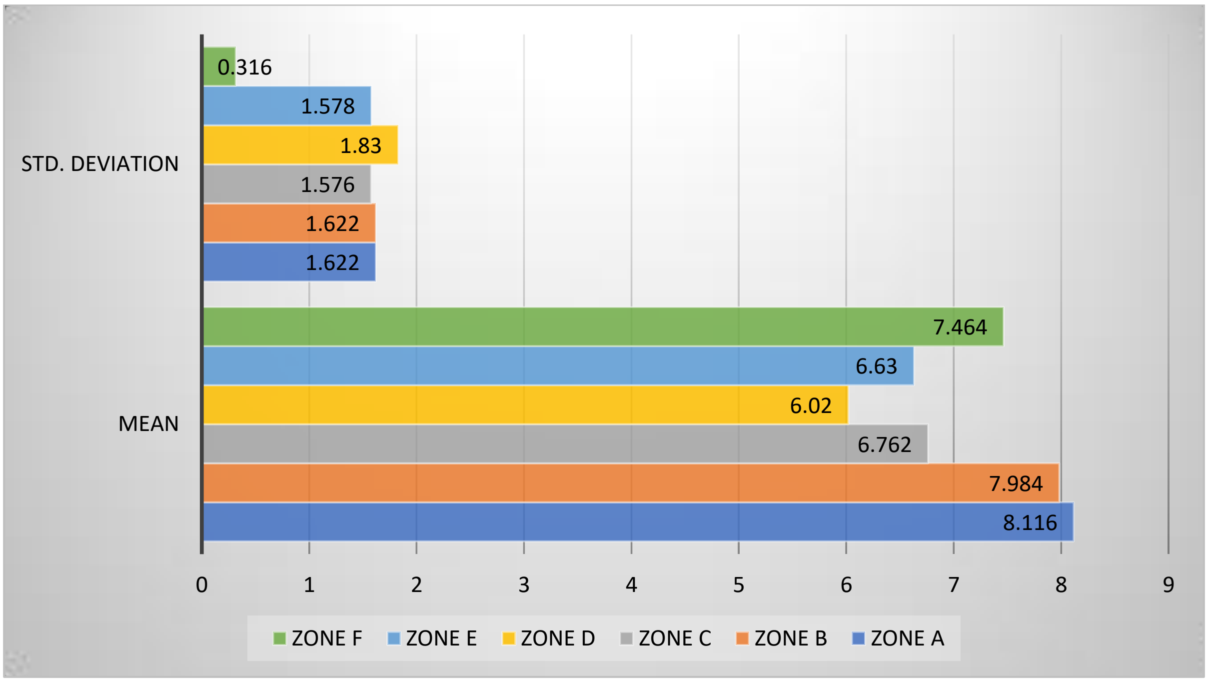


Figure 26: Angular Velocity of shoulder for Layup Shot in Basketball with Respect to Different Zones for Female Basketball Players

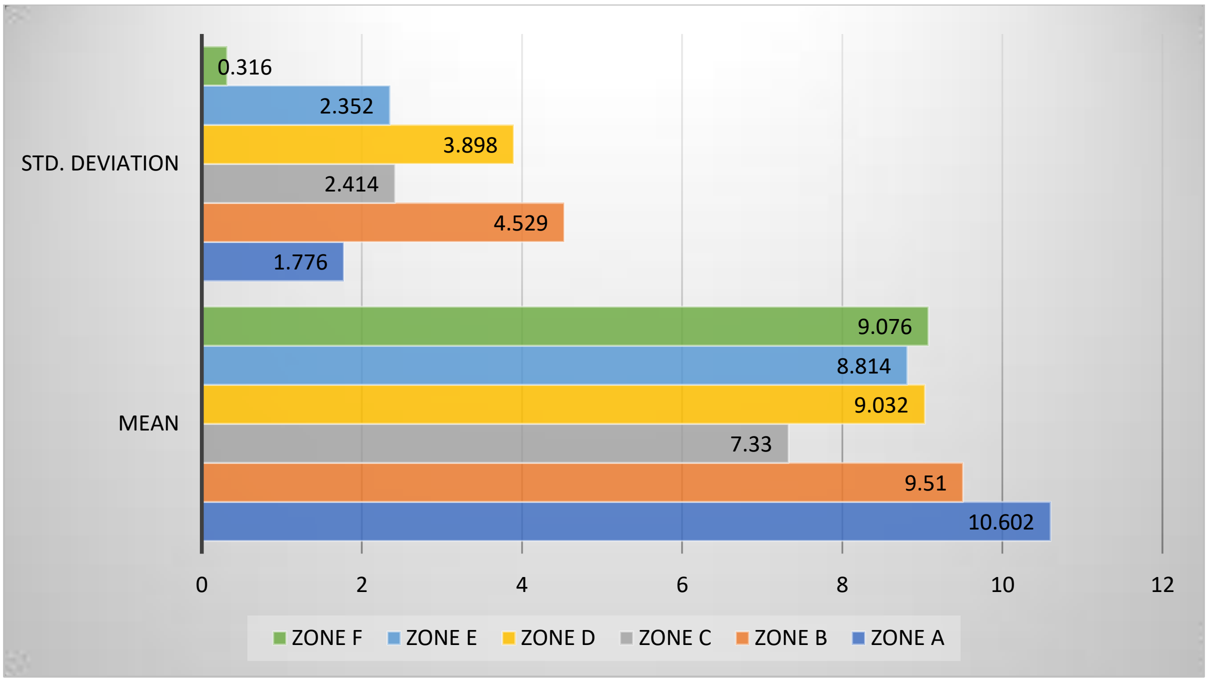


Figure 27: Angular Velocity of elbow for Layup Shot in Basketball with Respect to Different Zones for Female Basketball Players

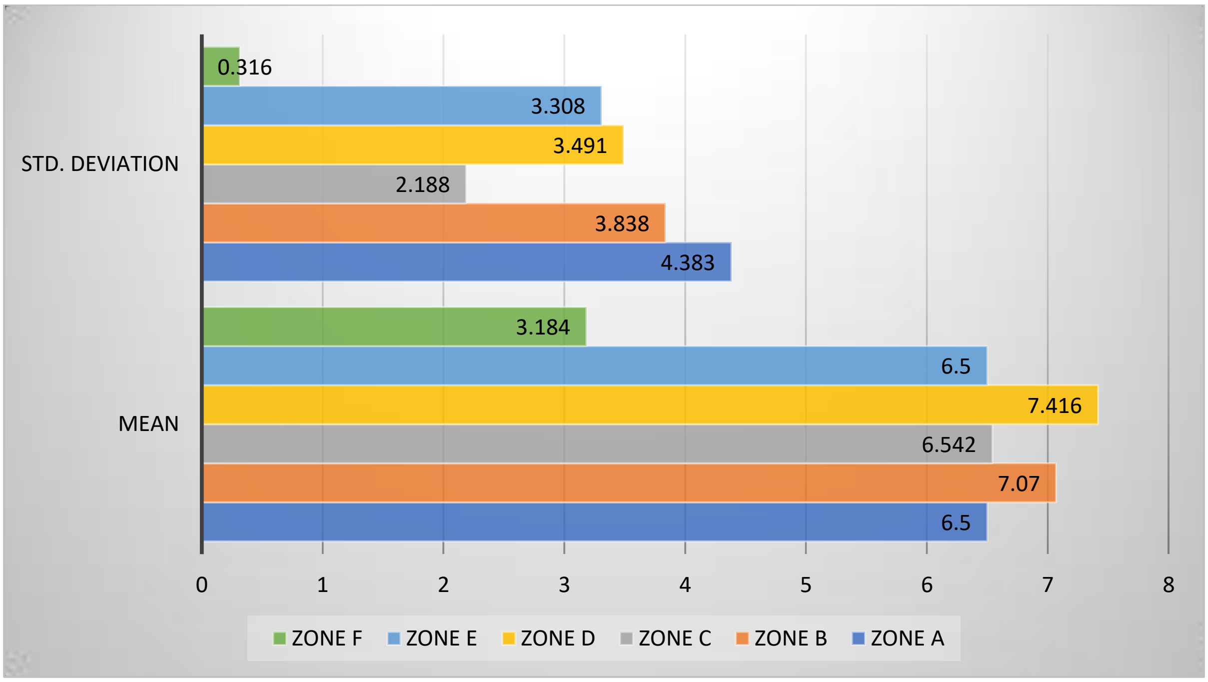


Figure 28: Angular Velocity of wrist for Layup Shot in Basketball with Respect to Different Zones for Female Basketball Players

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.

Duration of total flight for layup shot in basketball with respect to different zones in the two point field goal area for male and female players has shown in figure 29 and 30 respectively

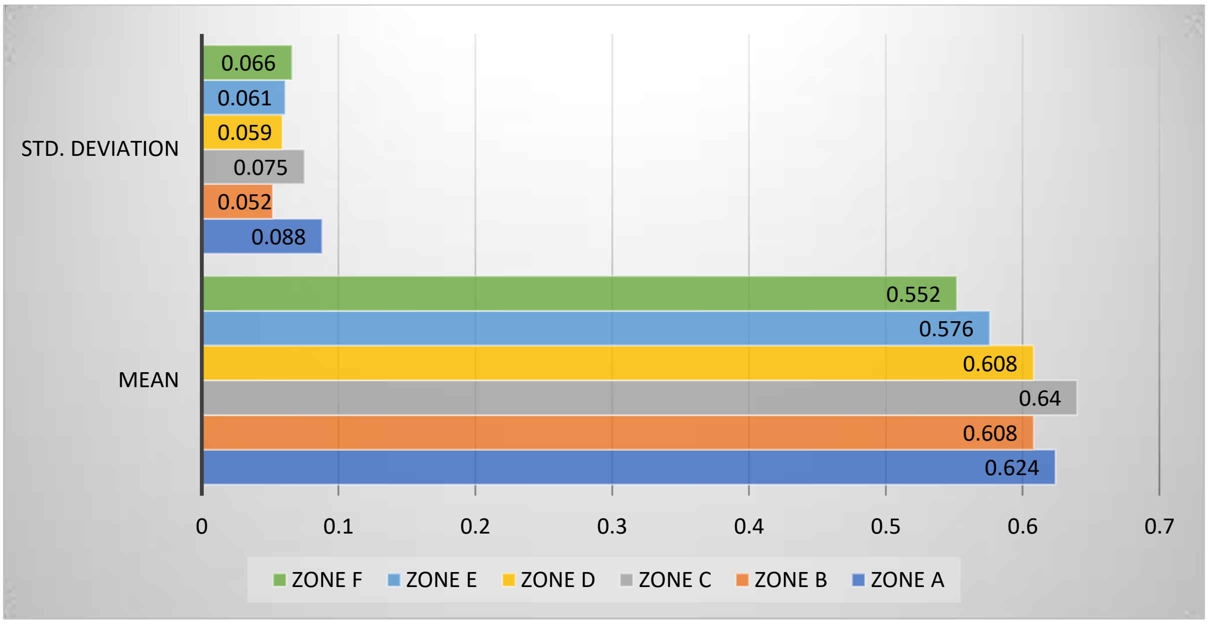


Figure 29: Duration of total flight for Layup Shot in Basketball with Respect to Different Zones for Male Basketball Players

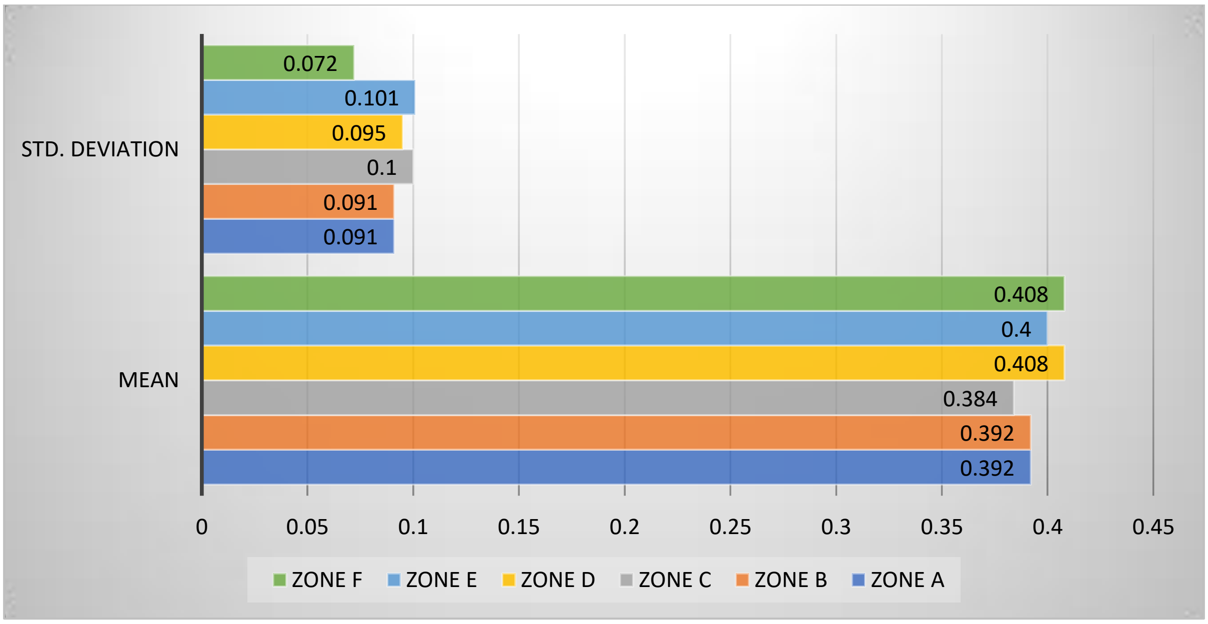


Figure 30: Duration of total flight for Layup Shot in Basketball with Respect to Different Zones for Female Basketball Players

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 for layup shot in basketball with respect to different zones in the two point field goal area for male and female players has shown in figure 31 and 32 respectively

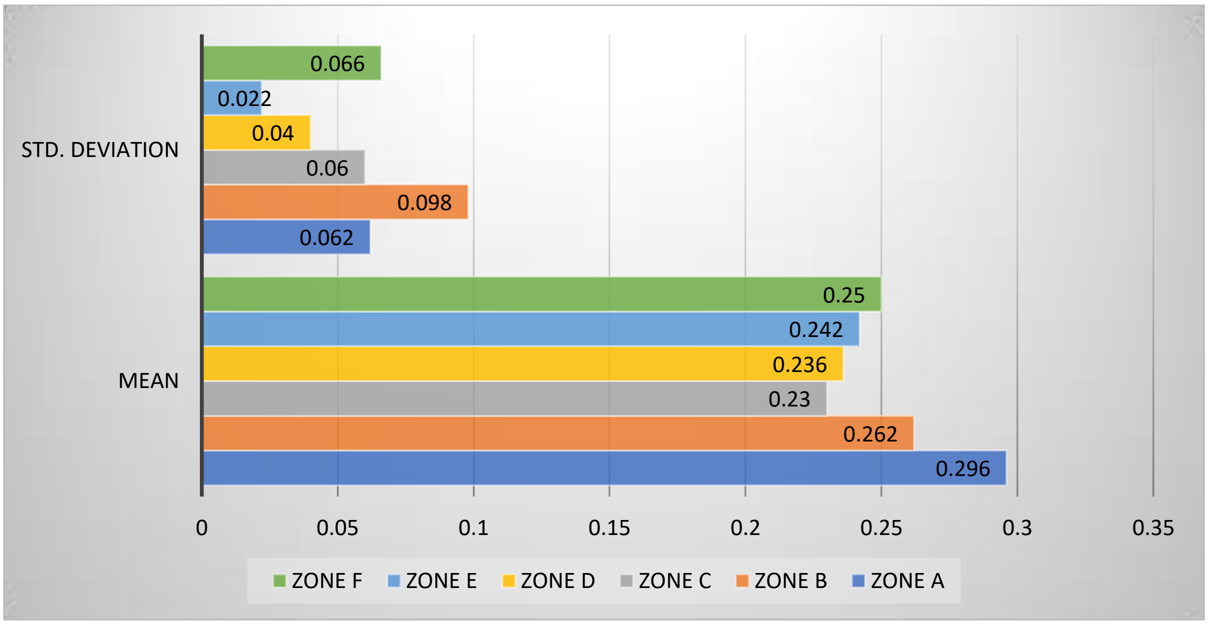


Figure 31: Lowering of C G for Layup Shot in Basketball with Respect to Different Zones for Male Basketball Players

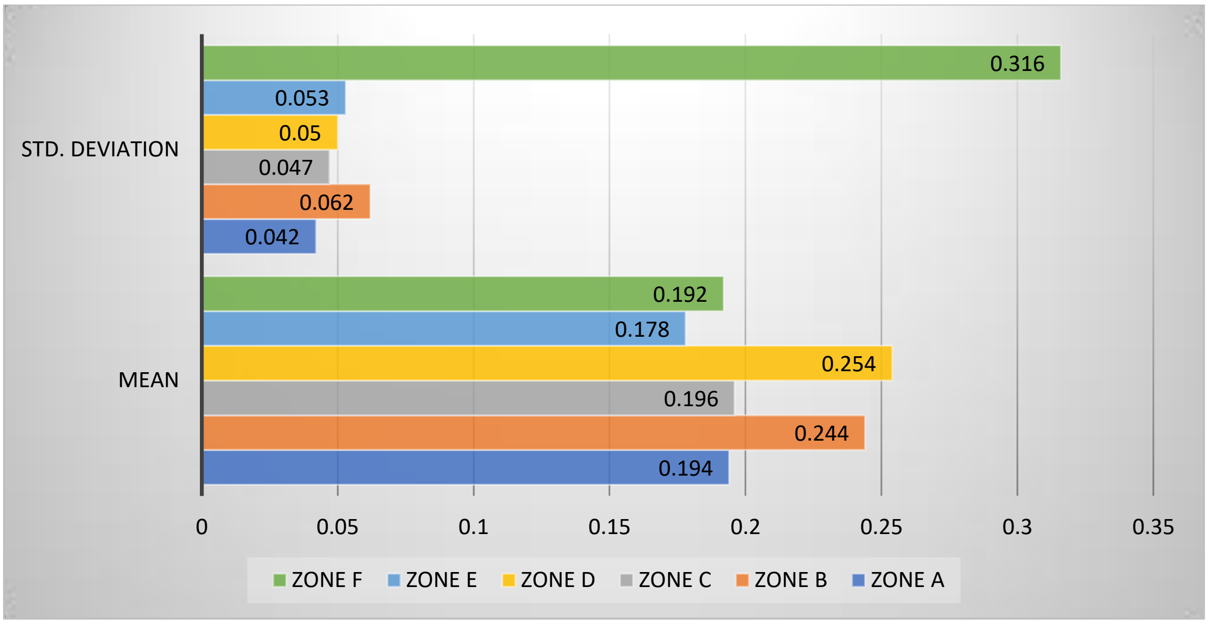


Figure 32: Lowering of C G for Layup Shot in Basketball with Respect to Different Zones for Female Basketball Players

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.

4.5 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.

CHAPTER 5

SUMMARY, CONCLUSION AND RECOMMENDATION

Chapter-V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary

The prosperity of a nation depends on the health of its people. Because we all know that having good health not only makes us feel happy but also gives us the energy to do our job in the best possible way. That will assist us to make our wealth. Significant achievements in man's life depend on both physical and emotional well-being. And to maintain the well-being sports is the best choice. As a result, there must be a heavy emphasis on sports. We should engage ourselves with all kinds of sports because it keeps us engaged and connects us with other people around us. Sports cultivate a true sense of community and assist us in achieving our personal best every time, whether we are only doing them for fun as amateurs or professional athletes. Many sports require a lot of physical activity (for example, running), and some sports require you to play in a team (such as Basketball). We can enjoy sports recreationally or professionally.

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. Understanding a little of the science in our favourite sport can help us build on and achieve more of our natural skills; it can help us run more quickly, swim more quickly, or pull out neater tricks. Sport success is not only the case in science, but also in many other factors such as physical skills, natural talent, endurance, courage and determination (and sometimes much more so). Even science is not fun to play but it adds an additional level to our understanding and helps us to appreciate even more our incredible sporting stars.

Basketball is a non-contact team sport played on a rectangular court by two teams of five players each. 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. In India, the game of basketball started its journey in 1930 when it was played for the first time. 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. In course of time, it became a popular game in the schools and colleges. Inter-collegiate Inter-university and national championships are being held in this game in several places.

The game has many individual techniques for displaying skill—ball-handling, shooting, passing, dribbling, layup, dunking, shot-blocking, and rebounding. The layup is considered the most basic shot in basketball. The layup shot for goal is most commonly used if a player is dribbling towards the basket and doesn't want to pass the ball and can get around the defenders. Its accuracy is also a cause for why it is so popular. For a player to improve their layup, improve accuracy, make the shot more efficient and speed up the run into the shot it is important to look at a few biomechanical principals. Learning how to shoot a effective basketball lay-up is an important task for all basketball players and can help to make them all a better well rounded player. However there are many biomechanical principles involved in performing an efficient basketball lay-up. These principals tell us how to move our body efficiently and improve our skills. These principles of basketball layup has been mechanically analyzed by the various researchers, but the scope of research has not been ended. An inspection of the layup shot of the national level players may provide some useful information regarding optimal technique, so that other skilled players will be able to emulate these skills and improve their own technique, skill and accuracy. Therefore, the purpose of this study was to analyze and compare the technique of layup shot from different field positions in the two point field goal area of national level basketball players on the basis of some selected kinematics parameters. So, the problem was entitled as "**A BIOMECHANICAL ANALYSIS OF LAYUP SHOT IN BASKETBALL FROM DIFFERENT FIELD POSITIONS**". Here the main intention was to analyze the biomechanical principles involved in a basketball lay-up shot separately for right hand lay-up shot in case of national level male and female basketball players.

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. All of them were represent national level championship in basketball and they were active participants during the time of data collection.

There were some uncontrollable limitations exists in this study such as non-availability of high speed cine camera, sophisticated instruments and the motivation, interest and arousal level of the players to perform the best during the test.

Keeping the feasible criteria in mind, especially availability of instruments and software, some anthropometrical and kinematical variables were chosen for the analysis of lay-up shot. The anthropometrical variables chosen for the study were weight, height, leg length, arm length and two hand distance. Some kinematical variables like 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 (ankle joint. knee joint, elbow joint, wrist joint & shoulder joint), duration of total flight and lowering of CG were selected for the study.

The anthropometrical variables i.e. weight, height, leg length, arm length and two hand distance were measured using weighing machine, stadiometer and steel tape. And for the purpose of data collection for kinematic variables three cameras with tripod stand- Nikon D3300 Nikon D5100 were used at a normal frame rate.

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.

To analyse the data, Kinovea-0.8.24 software was used. SPSS Software was used for to calculate ANOVA with LSD (Least Significant Difference) post hoc test to determine the means significant difference.

All the selected subjects were asked to perform the lay-up shot from different zones. The subjects were well directed and informed about the study and were well prepared for the study. They were asked to perform the lay-up shot in the natural way as they actually perform in between the given zone as it was described earlier. It was ascertained that subjects possess reasonable level of technique. The selected subjects were national players and had performed in the various National basketball championships. The execution of layup shot by the players were video graphed in the outdoor basketball court of Jadavpur University, with systematic filming method as required. The subjects were asked to attempt three valid lay-up shots and after every attempt the ball was supplied to him for next attempt. For the purpose of analysis only the best lay-up shot was taken among the three. The performance of each subject was obtained as mentioned in criterion measure. Sufficient numbers of practice trials were also given.

The result showed that for the female basketball players, variables like approach speed, two and half step length, takeoff velocity and horizontal velocity at take off had noticeable variation for performing the layup shot from different zones of the two point field goal area in the basketball court. Whereas the male basketball players had no alteration in approach speed, two and half step length, takeoff velocity and horizontal velocity at take off for performing the layup shot from different zones of the two point field goal area in the basketball court. On the other hand for the male basketball players, speed of ball release has markedly difference in layup shot from various zones of the basketball court but the female basketball players don't had any variety in that. The other parameters like the takeoff angle, angle of ball release, height of ball release, angular velocity of ankle, knee, shoulder, elbow and wrist (at the time of release), duration of total flight and lowering of C.G doesn't had any considerable alteration in performing the layup shot from different zones of the two point field goal area in the basketball court, for both of the male and female basketball players.

5.2 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.

5.3 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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APPENDICES

APPENDICES

SUBJECTS

1. MALE SUBJECTS:

M1- RITIK SINGH

M2- MANISH RAJAK

M3- ANKIT PANDEY

M4- UTSAB DAS

M5- ARKA SAHA

2. FEMALE SUBJECTS:

W1- RITUPARNA DAS

W2- RITTIKA DUTTA

W3- ASMINA KHATUN

W4- PRIYANKA GHOSH

W5- TANIA DEBNATH

FEMALE SUBJECTS

MALE SUBJECTS

RESEARCHER AND THE SUBJECTS

DATA COLLECTION

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Importance of biomechanics in Basketball layup shot

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Abstract
Biomechanics is the study of human movement, using principles of mechanics & applied anatomy. Biomechanics can effectively refine sports activities and promote athletes' scientific training. The theory teaching and practice of biomechanics are combined to promote the coordinated development of the athletes. In today's competitive Sport, the difference between winning and losing is getting slimmer by the day. The Biomechanics helps to achieve a competitive edge through analysis and identifying strengths and weakness of sportspersons and suggesting remedial measures to correct defects if any. Basketball is one of the most popular and widely viewed sports in the world. Points are scored by throwing the ball through the basket from above, the team with more points at the end of the game wins. For offensive side, achieving a fast break or finding an opening in a weak defense can result in a layup. For a player to improve their layup, improve accuracy, make the shot more efficient and speed up the run into the shot, it is important to look at a few biomechanical principals. These principals tell us how to move our body efficiently, improve our skills and rectify faulty actions. The knowledge of biomechanics helps the players, coaches and the related persons to enhance the basketball layup shot.

Keywords: Biomechanics, Basketball, Lay-up shot.

Introduction

Biomechanics is the study of human motion. It is the branch of Kinesiology which deals with the precise information of human Movements with scientific method. In sports biomechanics is a quantitative based study and analysis of movements of professional athletes and sports activities in general. In biomechanics the laws of mechanics are applied in order to gain a greater understanding of athletic performance through mathematical modeling, computer simulation and measurement. Biomechanics can effectively refine sports activities and promote athletes' scientific training. The theory teaching and practice of biomechanics are combined to promote the coordinated development of the athletes. In today's competitive Sport, the difference between winning and losing is getting slimmer by the day. The Biomechanics helps to achieve a competitive edge through analysis and identifying strengths and weakness of sportspersons and suggesting remedial measures to correct defects if any. Biomechanics is the study of human movement, using principles of mechanics & applied anatomy. Its main role in sport is to reduce the risk of injury, to obliterate the unwanted physical actions and to improve the performance of the athletes by identifying and applying optimal technique. Biomechanical analysis is an on-going and continuous process in guiding sportspersons through their rigorous requirements to stay at their best physical and technical shape.

Basketball is one of the most popular and widely viewed sports in the world. Points are scored by throwing the ball through the basket from above, the team with more points at the end of the game wins. The ball can be advanced on the court by bouncing it or passing it between teammates. Disruptive physical contact is penalized and there are restrictions on how the ball can be handled. Through time, basketball has developed to involve common techniques of shooting, passing and dribbling, as well as player’s positions and offensive and defensive structures. Typically, the tallest members of a team will play center or one of two forward positions, while shorter players or those who possess the best ball handling skills and speed, play the guard positions.

Basketball is a highly physical sport which requires a long period of high intensity physical activity and mastery over the skills. Players perform short sprints to intercept in defense or dribble the ball to the goal in offence. For offensive side, achieving a fast break or finding an opening in a weak defense can result in a layup. A lay-up is a shot where the players have to lay the ball up on the backboard or over the rim and into the basket. It can be done forwards, backwards or sideways. 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) [4]. 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) [4]. The layup is made with one hand and from a position under or beside the basket (Sandeep & Bhardwaj, 2011) [4].

Importance of Biomechanics in Basketball Layup Shot: The layup shot in basketball for goal is most commonly used and most missed shot. It is also the highest percentage shot a player can possible take in basketball. Lay-ups are the backbone of any team offense. If a player is dribbling towards the basket and finds a gap in defense and also he can get around the defenders, he should definitely go for the layup shot. Without the threat of a lay-up, all other shots would become next to impossible. Its accuracy is also a cause for why it is so popular. For a player to improve their layup, improve accuracy, make the shot more efficient and speed up the run into the shot, it is important to look at a few biomechanical principals. These principles tell us how to move our body efficiently, improve our skills and rectify faulty actions. The knowledge of Biomechanics will help the players, coaches and the related persons to enhance the basketball layup shot in following ways……

Identify the proper skill: Good technique in sport involves a well timed and coordinated sequence of muscle actions. Through the experience, adequate knowledge of biomechanics and the analysis provided by various research works, best techniques have been developed for many of the skills in sports. These techniques have evolved and been refined so that the movements involved produce the best performance and are least likely to cause injury. In the basketball layup shot various biomechanical parameters are involved. Like approach speed, take-off velocity, angular velocity, speed of ball release etc. Understanding of the exact implementation of those parameters will be beneficial for the players and coaches. Only the knowledge of biomechanics will help to achieve this.

Improvement in technique: The application of biomechanics to improve technique may occur in two ways: Teachers and coaches may use their knowledge of mechanics to correct actions of a student or athlete in order to improve the execution of a skill, or a biomechanics researcher may discover a new and more effective technique for performing a sport skill. One popular research of biomechanics that changed the sport of swimming was the study done by Ronald Brown and James “Doc” Counsilman in 1971. They indicated that the lift forces acting on one hand as it moved through the water is the key in propelling a swimmer through the water. Thus, instead of pulling the hand in a straight line backward, the swimmer should move his or her hand back and forth to produce propulsive life and drag forces. This technique in swimming has dramatically improved the way swimmers should swim through the water. Likewise, research workers in the field of biomechanics may develop a new and more effective technique for better execution of the basketball layup shot. This can improve the game and performance of the basketball players.

Improve in training procedure: Biomechanics can help to improve and modify the training procedure in two ways: By the analysis of mechanical values a coach defines such training conditions that may lead to threshold stimuli. We can use as an example the research project by Jandacka and Uchytil (2011) who carried out mechanical analysis of bench press with various loads in elite footballers. The recommendation resulting from this research project was as follows: Soccer players should train maximal strength during the preparatory period for their competitive season along with training for speed and endurance. By the analysis of technical imperfections of a given athlete the coach/teacher identifies the type of training needed for this athlete to improve. In case of basketball lay-up shot the required abilities to execute the motor task is not easy to detect so, the biomechanical analysis must be used.

Improvement of performance: The science of improving our performance involves neuromuscular skills, physiological capabilities, cognitive abilities and anatomical factors. Of course, it is hard to go through all of these. In this case biomechanics offer a simplified understanding onto how we can improve our performance by understanding the science of our movements. According to Knudson (2007), biomechanics is most useful in improving the performance of an athlete through improving the technique rather than relying on physiological capacity and physical built. By the knowledge of biomechanics they will able to know about the right techniques, effective and result oriented posture of basketball layup shot to get more efficient results by applying minimum muscular force.

Evaluation of performance: To evaluate any performance the coaches or trainers are effectively need to compare the observed performances with some model of good form. However, as there is no general optimal performance model. We need a model that is appropriate for the performers being evaluated – the model needs ‘individual specificity’. This clearly requires prior identification of critical features in the preparation stage. Furthermore, a ranking of the ‘correctness’ of the identified critical features on some scale or within some band of correctness can be very helpful. Research workers in the field of biomechanics may help to evaluate the technique of basketball layup shot and advice the proper technique for better execution of the basketball layup shot.

Distinguish the biomechanical parameters: Research works in the field of biomechanics will help to distinguish the biomechanical parameters necessary in layup shot from the different parts of the basketball field. The accurate Lay- up shot depends upon the physical fitness of the player, velocity of the ball, take off and height of release, the length and speed of first and second step etc. The proper knowledge of those parameters will help the basketball players to enhance their performance.

Knowledge of safety principles: Safety is in essence using good form when exercising, which, if we think about it, is applying correct biomechanical principles: if we are applying good force, our form and movement will also be good, which greatly reduces the risk of injury. In basketball layup safety principles are required to ensure that the game is incorporated with improve facilities and equipments. By the help of biomechanics we will able to analyze different movements that can be harmful for the players. So, the trainers or coaches will try to reduce or remove those unnecessary and harmful movements which are involve in basketball lay-up shot.

Reduce and prevent injuries: By injury prevention it is meant an attempt to prevent or to limit the seriousness of injuries before they are actually incurred. The concept of injury prevention is part of public health and its goal is to improve the general health of the population and thus to increase the quality of life. Biomechanics is a tool that can be used in sport medicine to identify forces and mechanical energy that cause injuries. It helps to understand how injuries originate, how to avoid them during sport performance, and how to identify exercise suitable for injury prevention and rehabilitation. Biomechanics offers possibilities to create alternative techniques of executing specific movements, using new equipment, and carrying out more effective training methods, which also contributes to injury prevention. Good examples of how biomechanics helps reduce the prevalence of injuries can be found in volleyball. Zahradník and Jandacka (2011) examined whether it is possible to adapt the landing after a volleyball blocking to reduce impact reaction forces acting on knee joints. They found that it is better for volleyball players to make one step back after blocking as opposed to staying on the landing spot and absorbing the relevant forces there. The basketball lay-up shot is a very injury prone skill. The knowledge of biomechanics will help to find out the factors or the forces that can lead to the injuries during the game situation. It also helps in reducing the sports injuries. Biomechanics offers possibilities to create alternative techniques of executing specific movements, using new equipment, and carrying out more effective movements, which also contributes to injury prevention.

For better rehabilitation: Rehabilitation from the injury is currently a very important goal of research in the field of games and sports. A study conducted by Kornelia Kulig and Judith M. Burnfield in 2008 shows the role of biomechanics in orthopedics, musculoskeletal and neurological rehabilitation. Specifically, their paper discusses selected examples, ranging from the tissue to whole body biomechanics level, that highlight how scientific evidence from the theoretical and applied sciences have merged to address common and sometimes unique clinical problems. The knowledge of biomechanics will help to understand how injuries originate, how to avoid them during the layup shot in basketball, and how to identify exercise suitable for injury prevention and rehabilitation.

Development of improved sports equipment: Use of biomechanics can also lead to a better look and better functionin2g of sport equipment. For example ski boots can have a real impact on sport performance. Sophisticated sport equipment gives advantage to both elite and recreational athletes. An introduction of the new vaulting equipment (vaulting table) after the 2000 Olympics represents the most substantial transition in the development of gymnastics equipment in the last decades. New vaulting equipment allows gymnasts to produce bigger angular momentum and thus to execute more complex vaults with multiple rotations around horizontal and vertical axes (Farana and Vaverka, 2010). Like that the knowledge of biomechanics will be used to modify and improve the equipment needed in basketball game as well as in the practice sessions, (like tee shirts, shoes etc.) to boost the performance.

Conducting new research work: Research is essential to find out which techniques work better for the layup shot in basketball. It plays an important role in discovering new processes, and making sure that we use existing techniques in the best possible ways. Research can find answers to things that are unknown, filling gaps in knowledge and changing the way that sports professionals work. Research works in biomechanics will also open the door of new possibilities by which the researchers will find new ways to improve the basketball game. Some of the common aims for conducting research studies in basketball layup shot are to - Diagnose problems in layup shot, prevent the development of wrong techniques and reduce the number of mistakes, improve the quality of basketball layup shot. Etc.

Increases the popularity of Basketball: Applying the knowledge of biomechanics, the basketball game may be getting more popularity by improving technique or skill, enhancing performance, reducing mistakes, eliminating risks of injuries etc. Research works in biomechanics will helps to promote the basketball game in the world.

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A STUDY OF TAKE-OFF VELOCITY IN BASKETBALL LAYUP SHOT

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A STUDY OF TAKE-OFF VELOCITY IN BASKETBALL LAYUP SHOT

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Abstract

The purpose of the study was to biomechanically analysis the take-off velocity in basketball layup shot from different field positions. For the purpose of the study five healthy national level male Basketball players (N=05) with no severe previous injury were taken as the subjects for the study respectively from west Bengal India. All of them were represented national level championship and they were active participants during the time of data collection. The age group of the subjects was ranged from 16 to 20 years.For the biomechanical analysis of take-off technique two cameras, properly inflated basketballs, motion analysis software (kinovea 0.8.24) and computer system were used.The two point field goal area of basketball court was divided into six equal zones.The subjects performed three lay-up shots from each zone (in fig. 1 these are A, B, C, D, E & F) and the best of those were selected for the purpose of analysis. The collected data were calculated by using ANOVA to compare between groups, and level of significance was set at 0.05 level. There was no significant difference on Take-off velocity of the basketball layup shot from different field position.

Keywords: Biomechanics, Take-off velocity, Lay-up shot, Basketball, Anova.

Introduction: The wealth of a nation depends on the health of its citizens. And to become healthy the practice of physical activities are very much important. Games and Sports are the most enjoyable form of physical activities. Sport is one of the top activities which bring total development for the people of any age. Not only physical, sports also help to improve brain activity as well, making it the best way to avoid numerous possible mental illnesses. Sport develops physical, mental, social and professional skills improving people's abilities to become united and goal oriented.

Biomechanics is the study of human motion. The study of biomechanics is important when determining what causes injuries and therefore how we can prevent them re-occurring. This is especially important in elite athletes but can be a major cause in recurrent injuries in the less gifted amateur athlete. Biomechanical analysis has become an on-going and continuous process in guiding Sportspersons through their rigorous requirements to stay at their best physical shape.

Basketball is one of the best sports in the world and it is also very famous. It is a team sport. Two teams of five players each try to score by shooting a ball through a hoop elevated 10 feet above the ground. The game is played on a rectangular floor called the court, and there is a hoop at each end. The court is divided into two main sections by the mid-court line. If the offensive team puts the ball into play behind the mid-court line, it has ten seconds to get the ball over the mid-court line. If it doesn't, then the defense gets the ball. Once the offensive team gets the ball over the mid-court line, it can no longer have possession of the ball in the area behind the midcourt line. If it does, the defense is awarded the ball. The ball is moved down the court toward the basket by passing or dribbling. The team with the ball is called the offense. The team without the ball is called the defense.

The object of the game is to win by scoring the most points. For scoring points the main techniques are —ball-handling, shooting, passing, dribbling, dunking, shot-blocking, and rebounding. Therefore, improving the team's shooting is important to win a game. There are several ways to score in the game among these a layup is considered the easiest shot, because it's taken so close to the basket that one can score every time. The Lay-up is one of the most widely used shooting techniques a player will need to learn.

A layup in basketball is a two-point shot attempt made by leaping from below, laying the ball up near the basket, and using one hand to bounce it off the backboard and into the basket. The layup essentially is the highest percentage shot a player can possibly take in basketball, yet it is missed again and again and again. But why is the layup missed so much?Well the answer is simple. Because of the nature of just how easy a layup is to perform, players fail to take the time to master the execution of a fundamental layup. At the end of the day, they cost their teams valuable victories and lower their potential points-per-game statistics.

A layup is a shot near the basket, usually off the backboard from different positions in the field especially from two point field goal area. For a layup, player runs towards one side of the basket, jump, and lay the ball off the backboard into both sides of the hoop with both his right and left hands from every sides of the court.In most instances, despite moving at a high rate of speed, the player must release the ball gently against the glass. Therefore, the first requirement for shooting good lay-ups is to eliminate all unnecessary movements and to master the take-off velocity by which he can jump to the suitable height from where he can easily put the ball into the basket by using backboard. The layup should be a high jump rather than a broad jump; therefore, the body movement must be transferred upward, instead of going forward. In order to achieve this, stretch out the last stride as the take-off foot is planted and with the next step a shorter one, lift the jumping leg hard with the knee coming high as you can lift it for take-off. The effective take-off with adequate velocity is very important for successful layup shot. In this study my intension is to, biomechanically analysis the take-off velocityin basketball layup shot from different field positions. And find out if there are any difference subsists in take-off velocity of the layup shot from different field positions. The jump simulations by Alexander (1990) and Seyfarth et al. (2000) indicate that the optimum take-off technique changes as the run-up speed is increased in vertical jump. In this instance my assumption is that there would be difference exists in take-off velocity of the layup shot from different field position.

Methodology: In order to find out the difference present in take-off velocity of the layup shot in basketball from different field position, fivehealthy national levelmale Basketball players (N=05)with no severe previous injurywere taken as the subjects for the study respectively from west Bengal India.All of them were represented national level championship and they were active participants during the time of data collection. The age group of the subjects was ranged from 16 to 20 years.For the biomechanical analysis of take-off technique two cameras, properly inflated basketballs, motion analysis software (kinovea 0.8.24) andcomputer system were used.The two point field goal area of basketball court was divided into six equal zones (each consists of 30^0 angle). For recording of movements of layup shot, the purpose of the recording was briefly explained to all the subjects for better understanding and to increase their motivation level. Each subject was instructed for warming-up at least 5 min. by stretching all major muscles groups for jump performance and several normal layup shots in front of the cameras. Each subject was instructed to perform three layup shots by dribbling the ball from the centerline and among them only the successful layup was taken for analysis. The movements of the subject for executing the proper technique was recorded by using fixed cameras for the different parts of the two point field goal area as shown in the figure below. The subjects performed three lay-up shots from each zone (in fig. 1 these are A, B, C, D, E & F) and the best of those were selected for the purpose of analysis. Then the video graphic analysis was done by using the software. After thatthe collected data were calculated by using ANOVA to compare between groups, and level of significance was set at 0.05 level.Thereafter the conclusion was drawn by the basis of the findings.

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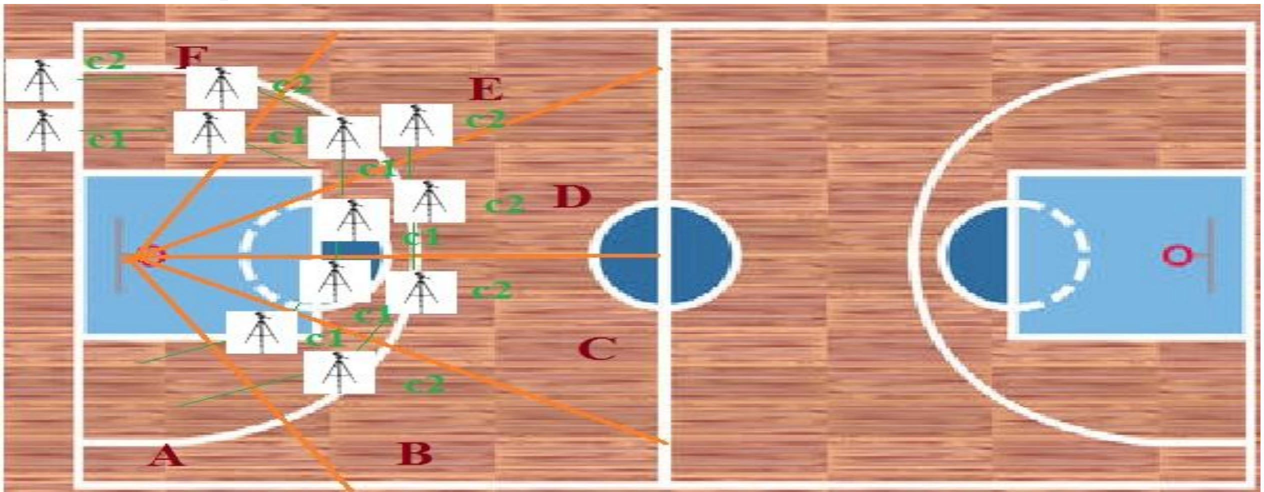


Fig: 1 Filming Environment for Collecting the Lay up Shot Action in Basketball

Analysis of data: To find out the difference in take-off velocity of the basketball layup shot from different field position, the take-off velocity was deliberated after dissecting the video of layup shot (Fig: 2 & 3) of each subject from different field positions by the help of software(kinovea 0.8.24).


Fig: 2


Fig:3

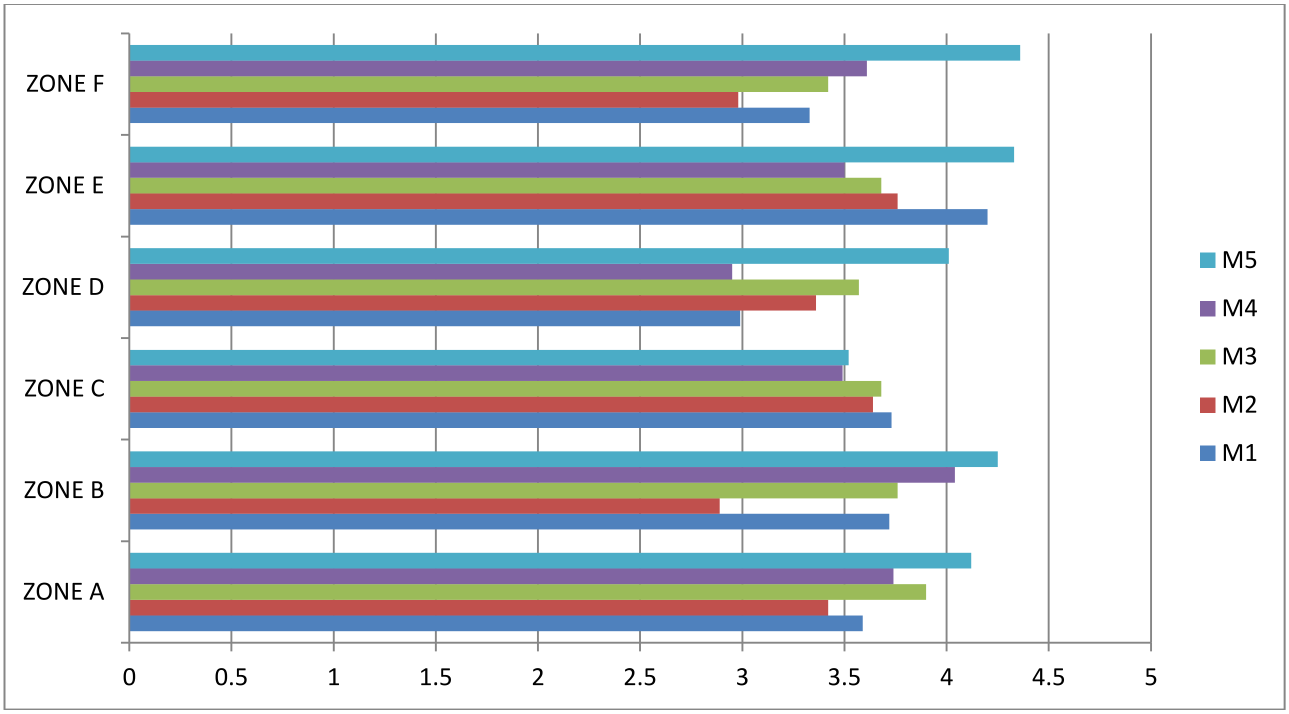
The value of take-off velocity was calculated in S.I unit.For the analysis of the present study, the collected data were computed by using ANOVA and level of significance was set at 0.05 level.

Results: The representation of the subjects' calculated measures of Take-off velocity of the basketball layup shot from different field position shows in The Table — 1.1. The data were calculated in S.I unit (m/s). Data pertaining to this table is represented in Graph-1.

Table 1.1: Measures of Take-off Velocity (m/s) with respect to different zones

ZONES	SUBJECTS				
	M1	M2	M3	M4	M5
A	3.59	3.42	3.90	3.74	4.12
B	3.72	2.89	3.76	4.04	4.25
C	3.73	3.64	3.68	3.49	3.52
D	2.99	3.36	3.57	2.95	4.01
E	4.20	3.76	3.68	3.50	4.33
F	3.33	2.98	3.42	3.61	4.36

Graph 1: Graphical presentation of theMeasures of Take-off Velocity (m/s) with respect to different zones

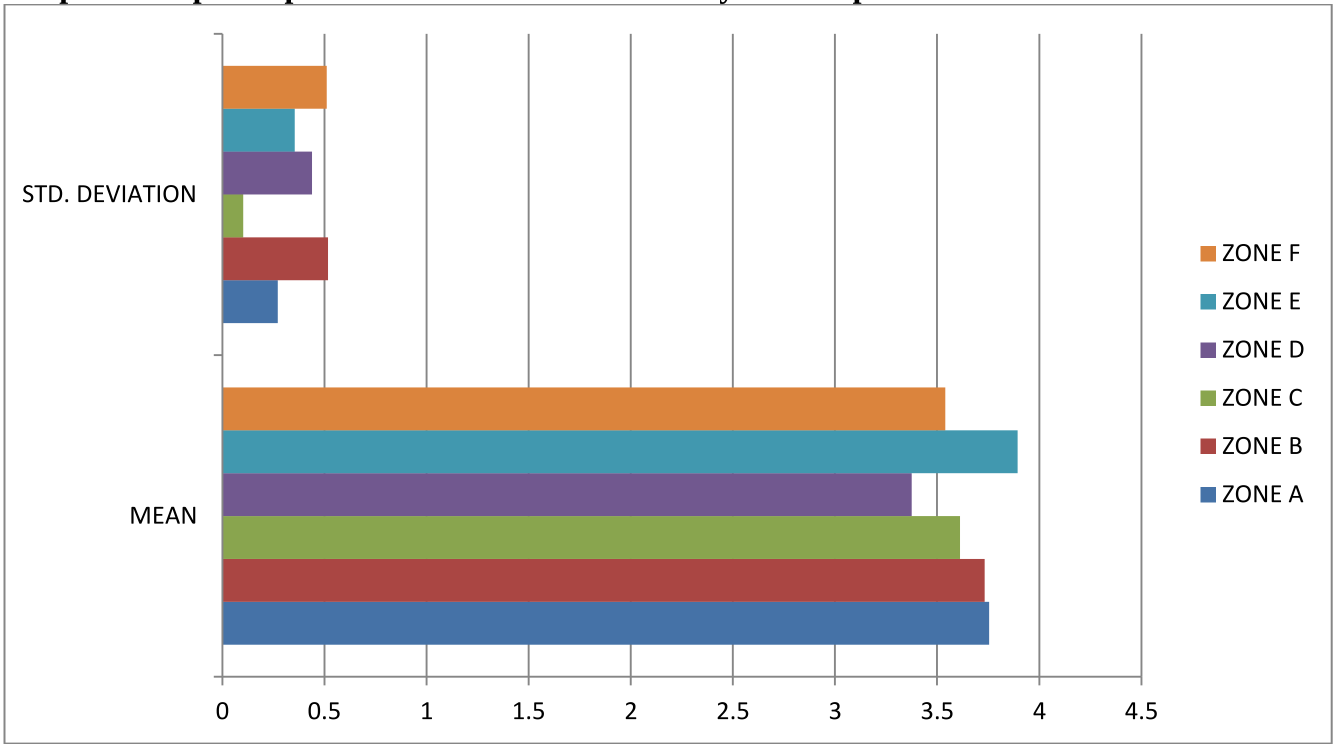


The representation of descriptive analysis that is mean and standard deviation from the subjects' calculated measures of Take-off velocity of the basketball layup shot from different field position shows in The Table — 1.2. Data pertaining to this table is represented in Graph-2

Table 1.2: Descriptive Analysis of Take-off Velocity with respect to different zones

ZONES	NO. OF SUBJECTS	MEAN	STD. DEVIATION
A	5	3.7540	.27107
B	5	3.7320	.51795
C	5	3.6120	.10330
D	5	3.3760	.43884
E	5	3.8940	.35451
F	5	3.5400	.51220

Graph 2: Graphical presentation of Take-off Velocity with respect to different zones



For calculating the F value to ascertain the significance difference exists between the Take-off velocity of the basketball layup shot from different field position ANOVA table was created . The F value was found insignificant as it's Sig. value (=.404) is greater than 0.05 thus the hypothesis of difference exists among the means of the subjects may be rejected. The presentation of ANOVA table was showed in The Table — 1.3.

Table 1.3ANOVA table for the data on Take-off Velocitywith respect to different zones

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.828	5	.166	1.065	.404
Within Groups	3.732	24	.156		
Total	4.561	29			

Discussions: The purpose of this investigation was to examine the difference of take-off velocity in basketball lay-up shot, from the various parts of two point field goal area. The measures of take-off velocity in basketball lay-up shot taken by the players from different field positions in two point field goal area shows no significant difference. The jump simulations by Alexander (1990) and Seyfarth et al. (2000) indicate that the optimum take-off technique changes as the run-up speed is increased in vertical jump. In this study the players were 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 no hurry to step up the velocity of take-off in their layup shot from different field position. The basketball lay-up shot is a frequently used but it's a tough shot to make because every time it is used, the shooter is approaching the basket at a different angle from various parts of the field. Besides that, there usually is a six foot six or a seven foot opponent waiting to jam it down their throat or swat it fifty feet up in the stands. As there were no opponent to diminish their motion, they were not in harsh to gain such a height that their opponent could not achieve. We also noticed that in most of the times despite of moving at a high rate of speed, the players were taking a smooth take-off and releases the ball gently against the backboard.

Conclusion: Within the limitation, the present study has increased our knowledge of the basketball lay-up shot. We found that there is no difference exists in Take-off velocity of the basketball lay-up shot from different field position.

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