Mechanics of the Basketball Free Throw

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The free throw is the single most important shot in the game of Basketball, as close to twenty per cent of all points in NCAA Division 1 Basketball are scored from free throws (Kozar, Vaughn, Lord, Whitfield, & Dve, 1994). The shot becomes more important later in the game, as free throws comprise a significantly greater percentage of total points scored during the last 5 minutes than the first 35 minutes of the game for both winning and losing teams (Kozar et al., 1994). The free throw should be one of the easiest shots in basketball (Okubo & Hubbard, 2006), since the player is all alone, 15 feet from the basket, with no defense and no close distractions. All the player has to do is get ready, aim, cock the ball and shoot. A skilled intercollegiate team should shoot at least 80 per cent from the free throw line, but very few teams are able to accomplish this task. Successful free throw shooting requires good concentration, but most importantly good mechanics in the shot. However, good mechanics alone cannot account for success in shooting free throws. (Kozar, Vaughn, Lord, & Whitfield, 1995) reported that practice free throw percentage for all free throws was significantly higher than game free throw percentage for an NCAA team over two seasons.

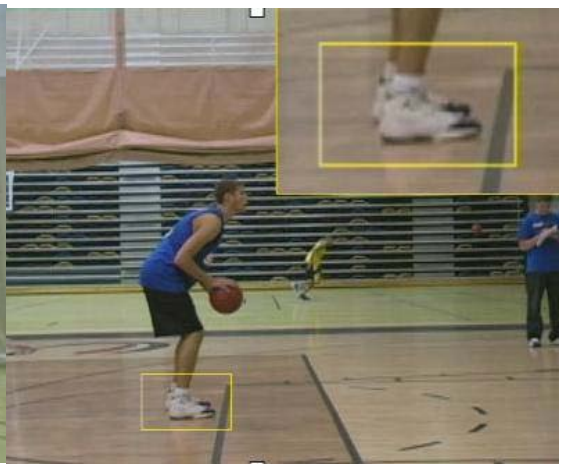
There are two basic styles of free throw used in basketball- the overhand push shot and the underhand loop shot. (Rist, 2000) favored the underhand loop shot due to the steeper angle of entry and smaller drift of the ball from better stability provided by holding the ball with both hands and applying greater spin at release. Greater spin caused the ball to rebound into the hoop more often than a shot with less spin (Reilly, 2006). One of the reasons the technique is not commonly used is that there is no carry over to the game other than to free throws; while the push shot is used for many other shots in the game. It also looks very different and unique and many players are concerned for their image while shooting (Reilly, 2006). The underhand loop free throw shot has seldom been seen in recent years, but Rick Barry was an NBA hall of fame forward who had a career average of 90% using the underhand style (Okubo & Hubbard, 2006).

This paper will focus on the push style of free throw as this is the commonly used technique for current players of the game. The push free throw will be broken down into five basic phases as described in the Level I NCCP Coach Certification Program (Coaching Association of Canada, 1980); preliminary movements, backswing, force producing movements, critical instant and follow through. The free throw will be described here for the right handed player, although the some of the photos show a left handed shooter. The subjects for this study were members of the University of Manitoba men's and women's basketball teams for the 2005 season who agreed to undergo a filmed skill analysis of their shooting and other basketball skills. Informed consent was obtained from all athletes in the study prior to the filming and subsequent film analysis. It should further be noted that female players use a slightly smaller basketball than the male players analyzed in this study. It has been reported that the smaller basketball is easier to handle and shoot for weaker players (Juhasz, 1982). The best trial for each athlete was selected for further analysis and breakdown, although it has been reported that there is little consistency is various measured angles for repeated trials in the free throw (Hayes, 1988).

Preliminary Movements

The preliminary movements for the free throw (R handed shooter) are very individual, and are slightly different for every player. Most players use these movements in order to mentally rehearse the shot they are about to take, and to attempt to relax and free the muscles of tension and tightness. The player will move up to the free throw line and place their right toe on the line. The left foot may be placed beside the right, or slightly behind the right in a staggered stance. The most commonly recommended stance is the slightly staggered stance, in which the front toe is on the line and the back toe is even with the arch of the right foot. A wider stagger in which the back toe is level with the back half of the foot or the back of the foot is not recommended here as it places too much weight on the front foot for the shot. However, some authors prefer the staggered stance with only a small amount of overlap of the feet (Ball, 1989). It is also acceptable to use the square stance in which the toes are both together on the free throw line.

The feet are placed close to shoulder width apart for the shot, or slightly wider apart depending on player preference. Foot placement too close together may produce balance problems for the shooter, as the base of support is then very narrow, while foot placement too wide apart will introduce a lateral component to the push of the feet on the floor. The most common preliminary movements consist of several dribbles with the shooting hand, keeping the wrist loose and the fingers and hand relaxed. The player rehearses in their mind the movements of the shot that are to follow, then picks up the ball in both hands for the shot. The shooter should spread the fingers so they will have better control of the ball, and place the fingers so they are directly behind the ball and not on the side of the ball (Hartley & Fulton, 1971). The wrist should be in extension (bent to the rear) in order to help support the ball and be in position to provide propelling force for the shot.



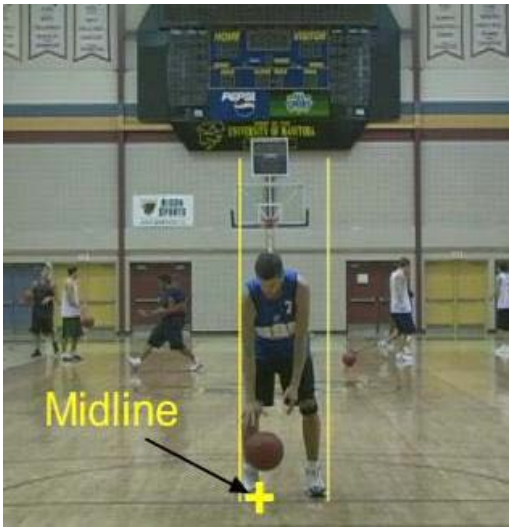


Figure 1. Preparatory Movements: Players prepare for the free throw by taking several dribbles while in position at the line, and then carefully sighting the target. Players use a staggered stance with the shooting foot slightly in advance of the other foot, feet are shoulder width apart.

Backswing

The backswing for the shot consists of the movements that occur during the crouch and preparation for the shot. The ball is held stationary at waist level with the shooting hand behind the ball. The shoulder of the shooting arm is close to zero degrees (parallel to the body) with the upper arm held along the trunk. The knees are flexed close to 90 degrees, the trunk is flexed close to 50 degrees from the vertical. The trunk flexion at this stage of the shot is very important, as the subsequent trunk extension is used for loading the legs by increasing knee and hip flexion just prior to the extension for the shot. As trunk extension occurs while standing, associated postural adjustments include hip extension and knee flexion to help maintain equilibrium (Oddsson, 1988). As the trunk moves from a flexed position to extension the upward moving trunk will push down on the lumbar vertebrae, which will push down on the sacroiliac joints, which will push down on the hip joints. This downward force will then be transmitted to the knee joints and produce greater knee flexion in response to the downward moving hips. Players who do not have the required trunk flexion at this stage of the shot will decrease their ability to load the legs for the shot using trunk extension and may lose the full contribution to the shot of leg extension from a deeply flexed position. It has further been suggested that trunk extension may help to trigger a more forceful knee extension moment (Fukui, Kim, & Takahshi, 2002). However, a deeper trunk flexion will produce more hyperextension at the neck so the shooter can retain focus on the rim. This neck hyperextension may produce unwanted tension in the neck muscles (trapezius) that may affect a smooth flexion motion at the shoulders during the shot.

Good jumping requires that the player pre-stretch the muscles thatcontract in the jump by executing knee and hip flexion prior to extension. When the player executes the knee and hip flexion and ankle dorsiflexion prior to a shot, the legs are flexed and the CG lowered. This crouched position will stretch the quadriceps and hamstring muscles to be used in the jump, and produce a more forceful extension. This more forceful muscle contraction during the shot is produced by two mechanisms: the stretch reflex and

possible elastic storage by the muscle. This stretch reflex is triggered when the muscle to be used is forcefully stretched prior to contraction. The quick crouch prior to a jump will trigger this reflex by firing the muscle spindles in the muscle that are sensitive to high velocity stretch in the muscle (Hamill & Knutzen, 2009). The stretch will produce a more forceful contraction due to this assistance from the reflex. However, some investigators (Hudson, 1986) suggest that the muscle, the connective tissue, and the tendon can store some strain energy during the pre-stretch, much like an elastic band. The muscle will then contract more forcefully during takeoff due to this stored energy. This mechanism may also occur during shooting, when the wrist is hyperextended prior to release of the ball. As the ball is brought up to forehead level prior to release, the wrist is hyperextended, which stretches the wrist flexor muscles. These muscles may then contract more forcefully during the release of the basketball, producing more backspin and velocity on the ball.

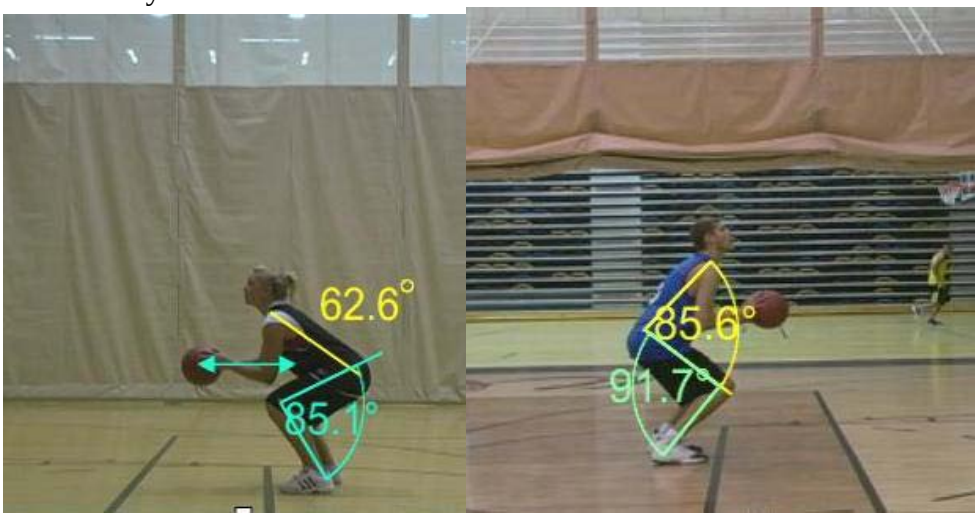


Figure 2. Backswing. Players show the correct amount of forward trunk lean and knee flexion prior to the shot. Ball should be held closer to the trunk in this female shot as this ball position produces too much shoulder flexion and elbow extension at this point in the shot.

Figure 3. Player shows good backswing position with knees and hips flexed, ankles dorsiflexed, trunk flexed forward, ball above shooting knee and feet shoulder width apart. Note that shoulder, hip knee and ankle of the shooting side are lined up vertically.

Figure 4. Player shows fairly good backswing except ball is too close to the midline rather than over the shooting foot, trunk flexion should be steeper, and feet are staggered too much.

Figure 5. Player shows a very large range of trunk and knee flexion, which is good for smooth production of force over a longer range of motion but may not be required for the fifteen foot free throw shot. This fully flexed position is more desirable than one with the body more upright and too much trunk and knee extension.

Figure 6. Player approaches the end of the backswing and starts the force producing phase of the shot. The trunk approaches full extension, ball is at shoulder level and moves up to the forehead.

The ball is raised up toward shoulder level by using shoulder flexion and the trunk begins to extend. As the trunk is raised from the flexed position to the near vertical position, this trunk extension causes the knees to increase their depth of flexion. Since the trunk carries approximately 50 per cent of the body weight, acceleration of the trunk upwards produces significant forces downward toward the floor. These forces can be used to increase the depth of knee flexion and dorsiflexion. As the trunk approaches the vertical position the ball is raised using shoulder flexion. Most authors advocate a vertical position of the trunk during release of the shot, compared to forward and backward lean which may be detrimental (Hudson, 1982). As the ball is raised and the shoulder is flexing, the knees will commence to flex to a deeper crouch. One of the roles of the initial shoulder flexion in the shot is to assist with the trunk extension and increased knee flexion. Although some shooters do not utilize trunk flexion at the beginning of the shot, this position is strongly recommended in order to assist with the loading of the legs for the release of the shot. One slight problem with too much trunk flexion is the neck may hyperextend at maximum trunk flexion to sight the basket- this position can lead to excessive tension in the neck muscles, especially the trapezius.

Another key position to be addressed in the free throw is the position of the non-shooting hand on the ball. This hand should be placed on the side of the ball and slightly behind the center, so the shooter is able to rotate the shooting shoulder forward to line up with the basket. Some players incorrectly place the non-shooting hand on the front part of the ball, and this position brings the non-shooting shoulder forward as well. With the non- shooting shoulder forward the trunk is too square to the basket, and it is difficult to line up the shooting arm and ball directly with the basket. The trunk must be rotated so that the shooting side is forward, and the non-shooting side is rotated backwards so the trunk is close to a 45 degree angle to the basket.

Figure 7. As the trunk extends toward the vertical the knee flexion is increased, shoulder flexion is increased and the ball is raised to chin level. Players are sighting over the ball.

Force Producing Movements

The force producing movements are the movements of the body parts that produce upward and forward force to project the ball to the basket, that include leg and

trunk extension as well as straightening of the shooting arm. During the force producing movements the ball is held in front of the body with the right shooting hand directly behind the ball, and the left hand to the side and underneath the ball. The fingers are well spread and the ball sits on the base of the fingers and the pads of the fingers, not directly on the palm. The force producing movements for the shot begin when the trunk reaches the vertical position and the ball is held just above shoulder level. At this point the knees are in maximal flexion and the vertical velocity of the ball is zero. From this position the first true force producing movements are the extension of the knees and hips and the elevation of the ball by shoulder flexion. The timing of the movements are that the knees and hips are extended first, followed by shoulder flexion, then elbow extension and wrist flexion. One error sometimes seen during the force producing movements for the shot is excessive shoulder girdle elevation in which the shoulders are brought upwards closer to the ears. This position of excessive tension in the trapezius can lead to excessive shoulder and neck tension, and may interfere with smooth shoulder flexion during the shot. Another error sometimes seen during the trunk extension phase is trunk hyperextension occurring in the lower back. This appears as excessive lumbar lordosis, or excessive curvature of the lumbar spine (Figure 7). This position can lead to lower back strain from excessive tightness in the spinal extensors.

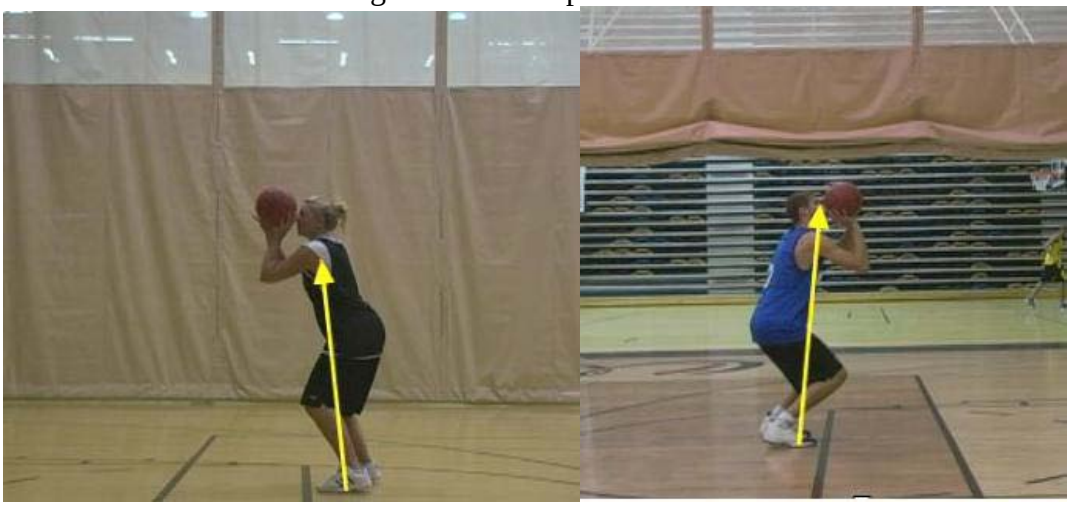


Figure 8. Knees and hips are extending as trunk approaches vertical and shoulder is flexing upwards. Elbow and wrist angles are constant as they have not yet begun to make their contributions.

As the knees are extending, the shooting shoulder is flexed (the upper arm is raised upward) to the horizontal position so that the upper arm is almost parallel with the floor (Figure 8). As the upper arm is raised to the horizontal the elbow flexion is increased to close to 130 degrees of flexion. Much of the power for the shot comes from extension of the elbow and the flexion of the wrist at release (Hartley & Fulton, 1971). The wrist also should be positioned into extreme hyperextension as the ball is raised above the head to maximize the range of flexion that can occur during the shot. The wrist range of motion during the free throw shot has been reported to be 54 degrees (Vaughn, 1993). From this position with the ball at forehead level, the upper arm is raised to a more vertical position by means of shoulder flexion. This shoulder flexion movement is one of the most important for the shot, as it produces much of the upward force for the

elevation of the ball, as well as helping to cock the elbow and wrist to increase their range of motion. The average shoulder flexion range of motion has been reported to be 82 degrees for elite players (Vaughn, 1993). The shoulder flexion movement is followed by the extension of the elbow joint, which is also an important force producing movement in the skill.

One key to a skilled shot is for the player to hold the position of the elbow in flexion (bent) while the shoulder is flexing at the beginning of the arm movement. The average elbow flexion range of motion for the free throw has been reported to be 80 degrees for Division I male players (Vaughn, 1993). The elbow must be kept directly under the ball during elbow extension so the ball is pushed directly upward to the basket. The elbow must be kept close to the body and in line with the shooting shoulder, with the elbow directly under the ball and pointing toward the target (Haskell, 1985). Some players make the mistake of lining up their nose with the target and not lining up the shooting shoulder with the target. The ball must be kept lined up with the shoulder, and not with the midline of the body (Meyer & Litzenburger, 1974). The release point should be directly in front of the shooting side of the body, in front of the right shoulder and hip.

The sequence of the upper body should be: trunk extension, shoulder flexion, then elbow extension and wrist flexion together. A common error in shooting is to perform elbow extension and shoulder flexion at the same time, so there is a lesser contribution from elbow extension in the shot as it's contribution is combined with the shoulder flexion instead of adding to the velocity of the hand. As the ball is being brought up with both hands, it will pass directly in front of the shooter's eyes and the shot will actually be aimed with the eyes under the ball (Figure 11).
The wrist is held in hyperextension (fingers pulled back towards the face) during most of the elbow extension, the ball is then released during forceful wrist flexion from a hyperextended position. The ball moves up the fingers to the fingertips during release, with the index finger being the last to leave the ball(Haskell, 1985). Other authors have suggested that the ball leaves from both the index finger and forefinger of the shooting hand (Booher, 1990). All good basketball shots should be released with a forward flick of the wrist (wrist flexion) to produce backspin on the ball. Backspin is produced by an eccentric or off center force, a force that does not pass directly through the CG of the ball. In this case, the force is applied to the outside of the ball by pulling the fingers underneath the ball during release--this produces backspin as well as assisting the forward-upward trajectory of the ball. Backspin has two major roles in a basketball shot--it stabilizes the flight of the ball in the air, and it produces a softer rebound on contact with the backboard which may produce a score (Adrian & House, 1987). Any time a ball has spin on it, it carries a small layer of air around with it as it travels to the target--this layer of air stabilizes the flight of the ball by equalizing the air pressure on the ball from all directions. Any turbulence encountered by the ball en route to the basket will not affect its flight because the boundary layer of air protects it from this turbulence. The rotation on the ball should be three to three and a half times on the way to the basket (Haskell, 1985) or a rate of rotation of 3 Hz, or three revs per second (Tran & Silverberg, 2008). The ball should rotate around a left right axis parallel to the backboard, and it should have counterclockwise spin or backspin for a right handed shooter. Less rotation or sideways rotation will not stabilize ball flight and the ball may wobble en route to the basket.

As the wrist is being flexed, the lower arm is also pronating during release of the ball to impart more backspin to the ball in order to stabilize the flight. Pronation is recommended because it will help ensure that the spin is occurring around the left-right axis only, and no side-spin is imparted to the ball. If the lower arm moves into supination (hand facing the midline of the shooter), then there is often sidespin imparted to the ball that may produce erratic flight. If the wrist and hand movements are started before the elbow the ball will not receive proper backspin and will have no spin or spin around the incorrect axis, which will cause the ball to float like a knuckleball (Hartley & Fulton, 1971).

Critical Instant

The critical instant in shooting is the instant of ball release, since following release nothing the shooter can do will affect the flight of the ball. At release the trunk and legs should be fully extended, indicating that these joints have made a full contribution to the flight of the ball. Some players will leave the floor during release of the ball, indicating a forceful push off from the floor. If the player leaves the ground during release of the shot, the feet should land in the same spot as the takeoff. A common error in shooting is to float slightly backwards or forwards at release, leading to a landing behind the point of takeoff. The trunk should be vertical and not leaning forward or backward during the release and follow through of the shot (Penrose & Blanksby, 1976).

The shooting shoulder should be in 140-150 degrees of flexion, a position in which the shooting shoulder is almost pointing vertically to the ceiling. A good coaching cue is to look for is a near vertical shooting arm as the ball is released, to ensure optimal vertical velocity is imparted to the ball. The elbow should be approaching full extension at release, to ensure that this joint has made a full contribution to the flight of the ball. It has been reported that a full range of elbow movement is related to greater success in the free throw of club level basketball players (Stankovic, Simonovic, & Herodek, 2006). However, there will be slight flexion in the shooting elbow, as the ball is released at peak angular velocity of the elbow, and this occurs in mid range and not at full extension. The wrist should be in mid flexion at release, a position halfway between full extension and full flexion to ensure that the hand is moving at maximum velocity as the ball is being released. If the ball is released too early or too late, the velocity of the ball will not be optimum as the wrist and elbow joints will be speeding up or slowing down rather than being at peak velocity. Wrist flexion provides the final thrust for release of the ball and helps determine both the velocity and angle of projection of the ball (Hess, 1980; Martin, 1981).

The non shooting hand should drop off the ball just prior to the instant of release (Hartley & Fulton, 1971; Penrose & Blanksby, 1976), so that the shooter can retain control over the ball as long as possible. A study of jump shooters revealed that top players removed the non-shooting hand from the ball significantly later than did the average group (Penrose & Blanksby, 1976). As the wrist is flexing for release, the non-shooting hand will drop off to the side of the ball with the palm facing the ball. It is important that the non-shooting hand remain in position facing the ball during release, so that it does not impart any unwanted sidespin to the ball from lower arm supination (hand facing backwards) or pronation (hand facing forward) during release. A common error in shooting is to rotate the non shooting hand to face forward or backward as it comes off

the ball, to the possible detriment of the shot by imparting unwanted off center forces to the ball at release.

Figure 9. Player has dropped the non-shooting hand from the ball early, which may lead less control over the ball through release. Shoulder is flexing while the knees continue to extend.

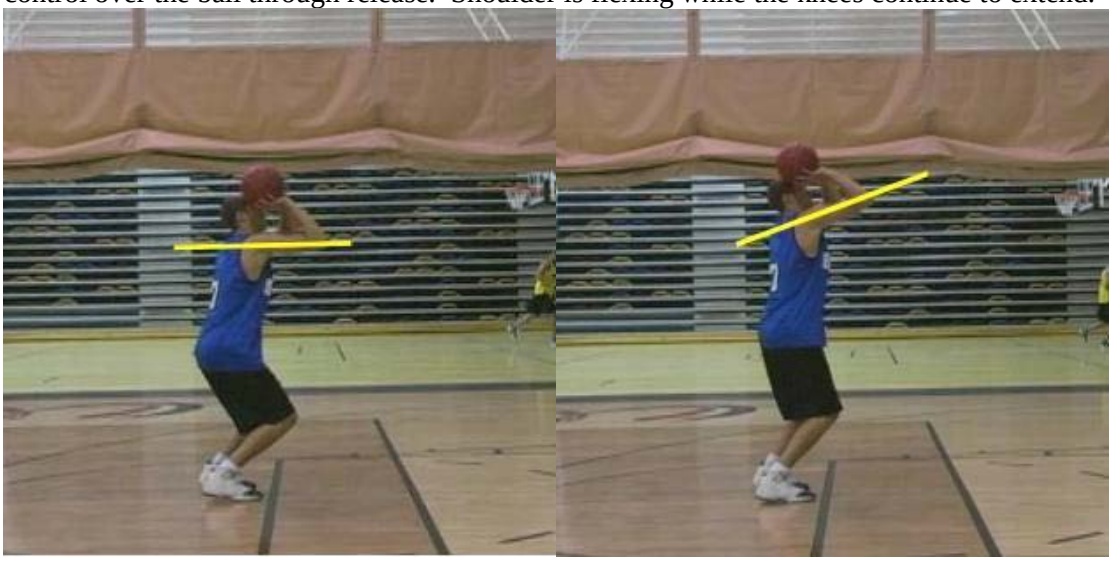


Figure 10. Player has extended the trunk and the knees are extending while the ball remains stationary above the forehead. Shoulder flexion angle is moved to above horizontal and elbow flexion remains optimal; this is an excellent shot because the elbow remains flexed as the knees are extended and shoulder flexion begins.

Figure 11. Player has extended the trunk and is sighting under the ball that is just off the forehead on the shooting side. Shooting shoulder, knee and hip are well lined up with the ball, the shooting elbow should be moved closer to the midline. The non- shooting elbow is also too wide and should be rotated toward the midline.

Arch of the Shot

After the ball leaves the shooter's hand it becomes a projectile that has a parabolic pathway to the basket. The ball can reach the basket with a high arch or a lower arch, with the higher arch giving the greatest chance for the ball to go into the basket. As most coaches have by now determined, the most effective arc for a successful shot is one which is as high as possible--the closer to 90 degrees the angle of approach of the ball to the hoop, the greater the probability of making the score.(Brancazio, 1984) has suggested that a good technique for coaches to use in evaluating the arc of the shot of their players is to stand near the sideline, and watch the flight of the ball. If the arc of the ball is at least at the height of the top of the backboard, the arc is sufficient. If the arc does not reach the top of the board, the shot is probably too flat to be consistent. However, the amount of arc on a shot is also related to the strength of the player, and some players may not have sufficient strength to attain a high arc from past 15 feet from the basket. A higher arched shot requires more strength to generate the vertical velocity required for the attainment of a greater peak height. The optimal vertical velocity for a basketball free throw is between 6.0 and 6.3 m/sec, depending on the height of release; with an angle of release of 50-55 degrees (Brancazio, 1981). The theoretical angle and speed of release was determined experimentally to be 60 degrees and 7.3 m/s, but these values have not been measured directly from skilled players (Hamilton & Reinschmidt, 1997). A computer model of the ideal free throw for a player 6 feet 6 inches tall is 52º from the horizontal (Tran & Silverberg, 2008); most shooters shoot with a lower angle of release than the optimal. In the two groups of elite university players in the current study, over 80% of the players shot at an angle of between 45- 50 degrees. A higher vertical velocity would require significantly more muscle force, which would require a larger range of motion from the legs and shooting arm and would differ markedly from the shot technique used in a game. In a game the player must try to release the ball as quickly as possible in order to prevent the defense from blocking the shot.

Figure 12. Shooting shoulder, elbow, hip, knee and ankle are lined up as ball is raised for the shot. Non shooting elbow is out too far to the side; back foot is pointing to the left instead of straight ahead.

Figure 13. Knees and hips are fully extended, ankles are plantarflexed, and trunk is straight as elbow extension is starting to make a contribution to ball speed. Elbow could move in slightly more under the ball; non-shooting hand retains contact with the ball but elbow is too far out to the side.

The release of the basketball must be accompanied by relaxation in the muscles of the shooting arm, with no excessive tension in the shooting arm or wrist and hand. Only the muscles required to project the basketball should be contracted; and all other arm and shoulder muscles should be loose and relaxed so as not to interfere with the action from

the hand and wrist. It has been reported that unsuccessful shots were associated with a longer muscle activation period, as measured using electromyography, suggesting that muscle tension should be minimal during release for success in shooting (Miller, 1999). Shots requiring the least amount of energy to be expended at release are the easiest to control and have the greatest probability of success (Huston & Grau, 2003). The player in Figure 13 shows a very relaxed shooting arm and hand, related to his effective shooting technique. In mechanically correct shots, the wrist, forearm, upper arm, and right side of the body will be in a straight line and perpendicular to the floor (Ball, 1989; Hartley & Fulton, 1971). All the resultant forces should be only in a straight line to the basket, so that the wrist and hand will not have to compensate for improper placement of the elbow. A common error made by many shooters is having the elbow pointing out to the side (excessive shoulder horizontal abduction) (Figure 12 & 13) rather than in a straight line with the wrist and hand (Hartley & Fulton, 1971).

Figure 14. Elbow extension is nearing completion while wrist remains in extension through release; shoulder flexion has reached the end of the range of motion, trunk has rotated to the left to line up shooting arm with the basket so number on his back is visible. Ball is rolling off the fingertips during release as elbow continues to extend and wrist is flexing. Fingers are moving forward under the ball to produce backspin.

Figure 15. Full extension of the shooting arm at release; ball is lined up with the shoulder, hip and knee of the shooting side; non shooting lower arm is incorrectly rotated forward (pronated) as it comes off the ball.

Figure 16. Full elbow extension and shoulder flexion at release; player holds the follow-through position after ball is released but has incomplete wrist flexion and pronation.

In the player in Figure 16, the shooting arm may be experiencing excessive tension in the wrist and finger flexor muscles muscles- the arm does not appear to be relaxed following release as fingers are extended and abducted and wrist is locked. The arm in the follow through should appear as it does in Figure 17, with the shoulder fully flexed, the elbow extended, the wrist fully flexed and fingers relaxed and slightly flexed at the knuckles (metacarpal-phalangeal joint). This position is often called the "goose-neck" pose, due to the fully extended arm (neck) and flexed hand; and is often used by coaches to check for the correct form in the follow through.

One key to effective free throw shooting is that the body remains erect and vertical during release of the ball (Penrose & Blanksby, 1976). This will ensure optimal vertical velocity is imparted to the ball at release, and will be conducive to a higher release point. The higher the ball is released, the less time it is in the air before reaching the basket and the less time for off line velocity to act. Since most male players release the ball from a higher point than most females, the optimal release velocity is less for most males (6.0 m/s) than for most females (6.35 m/s) (Satern, 1993). The higher peak height of release will give the ball a greater angle of approach to the basket, a larger diameter of hoop to fall through, and a greater chance of scoring (Hay, 1993). The closer the release height to the height of the basket, the smaller the projection angle needed and also the less the velocity of release needed (Kreighbaum & Barthels, 1996). Height of release has been found to be important to the success of the shot, as (Hudson, 1983) has noted that successful shots are significantly related to a height ratio calculated by comparing the standing height of the shooter to the height of the shooter's release. The higher the release height, the better the shot. Studies have reported that shots of highly skilled players are released higher than those of less skilled players; and a higher release is related to greater flexion at the shoulder which is desirable (Hudson, 1982). Successful shots were released an average of 4 cm higher than those that were

unsuccessful (Hudson, 1982). Higher release height is attained by greater shoulder flexion and elbow extension at release (Yates & Holt, 1983). This position gives the shooter a higher release point and a more vertical angle of ball projection.

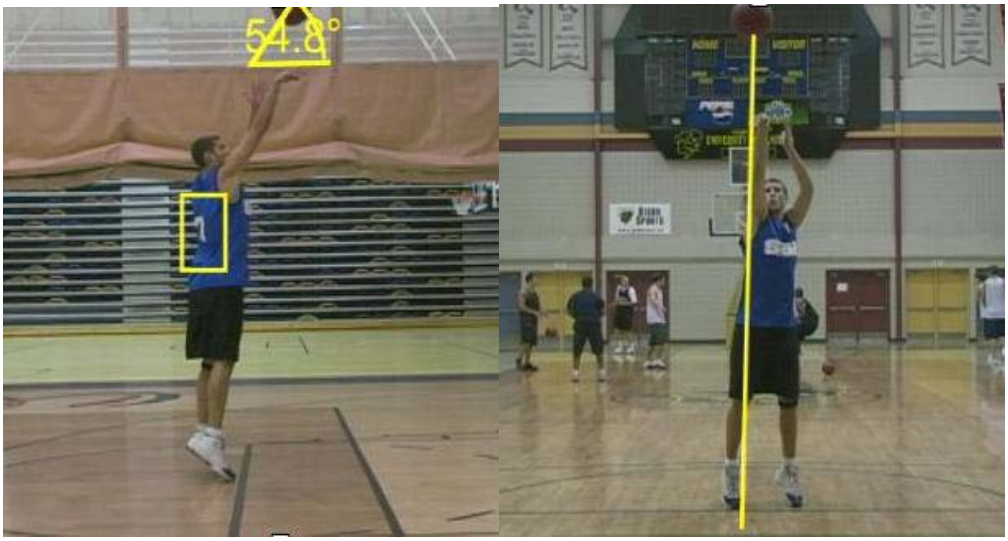


Figure 17. Controlled and balanced follow through with correct alignment of shoulder, hip and knee, good range of shoulder flexion, elbow extension and wrist flexion. Shooting arm is aligned with the shooting shoulder; trunk is rotated away from the shooting arm to line up with hoop but trunk is tilted slightly to the left.

Figure 18. Ball has left the hand but shoulder flexion, elbow extension and wrist flexion remain incomplete at release. Trunk should be vertical at release rather than leaning forward, knees should be fully extended.

Follow Through

The final phase of the shot is the follow through, in which all the joints continue to move through to the end of their full range of motion following release of the ball. In the skilled follow through, the legs are fully extended and the ankles are plantarflexed (toes pointing to the floor). The trunk is vertical and the shooting hip is lined up vertically with the knee and ankle, as well as with the joints of the shooting arm. The

shooting shoulder is in at least 140-150 degrees of shoulder flexion- the closer the upper arm is to the vertical the better the shot because the greater the vertical forces applied to the ball. This movement of the joints to the end point of their range of motion will ensure that the joints do not stop moving prior to release of the ball, which would decrease the release velocity of the ball. The trunk should be rotated away from the shooting hand, to line up the shooting shoulder and arm more directly with the hoop. This trunk rotation should occur during the release of the ball from the hand, as it is facilitated by the dropping off of the non shooting hand from the ball.

After the ball has left the hand the elbow should reach full extension, the wrist should be fully flexed, the lower arm should be in pronation and the fingers should be pointing slightly to the outside, indicating that pronation has occurred during the shot. The elbow extension and wrist flexion are responsible for application of upward force and spin to the ball at release, which will help to stabilize the flight of the ball on the way to the basket.

Common Errors in Free Throw Shooting

1. Poor Alignment- Many shooters fail to line up the shooting side hip, knee, shoulder and elbow with a line through the ball to the basket. If any of these joints is out of alignment the shot is more likely to be released off line and miss the basket.
2. Lack of Backspin- players often apply sidespin to the ball at release; or else apply no spin at release. Both of these errors will affect the flight of the ball and may cause it to go off line en route to the basket; or to rebound off the backboard too hard or sideways and not drop into the hoop.
3. Low arc on the shot- players who do not have sufficient shoulder flexion, elbow extension or trunk extension during release often release the ball too flat; a high arc is required to ensure the ball has the maximum area of the basket to utilize on entry.
4. Relaxation of the shooting arm- the shooting arm should be completely relaxed during the shot, with only the active mover muscles contracted and all others loose and relaxed. Too much tension in the non-mover muscles of the shooting arm will interfere with the smooth release of the ball and shorten the follow-through.
5. Full follow-through after release- players should finish in the full goose neck position of the shooting hand with the arm pointing to the ceiling and the hand pointing directly to the basket.
6. Interference from non-shooting hand - If the non shooting hand is pronated or supinated at release it may move the ball out of alignment with the hoop.
7. Ball shot too hard- When a player is excited or tired they may release the ball too fast and it will bounce off the back of the rim and miss the basket.
8. Too much tension in shooting arm- shooting arm should be in full shoulder flexion, elbow extension and wrist flexion at release of the ball. If muscles are tense it may decrease the range of motion of these joints and interfere with the shot

9. Taking off at an angle- Player taking off or landing at an angle to the floor- either forward or backward- will produce an off center jump and apply non-vertical forces to the ball. Takeoff and landing should occur from the same footprints.
10. Leaning at Release- Player is either leaning forward, backwards or sideways during the release of the ball, which will produce an off center force on the ball at release.

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