Does the “Dip” Increase the Accuracy of the Jump Shot in Highly Skilled Basketball Players?

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ABSTRACT

The present study assessed the jump shot performance of elite high-school and university students to determine whether or not the “dip” increased shot accuracy. There remains a debate between coaches who believe “dipping” is too slow and coaches who believe “dipping” increases accuracy. A mixed design was used for the present study with high-school and university players all performing shots with and without the “dip” at four distances: 3.125m, 4.925m, 6.025m, and 6.75m. Thirty-six athletes completed the study with accuracy being measured using Hardy-Parfitt’s (1991) six-point scale. Secondary dependent variables were collected, including shot speed and shot arc. The results of the present study indicate that the “dip” led to increased accuracy of the jump shot, showing a larger effect among high school shooters, compared to university shooters. This means that the shooter must determine whether using the “dip” and increasing shot accuracy, but reducing shot speed, which was also statistically significant, will be beneficial.

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LIST OF ABBREVIATIONS

The following table includes the abbreviations used throughout the thesis. The page on which each one is first used is also given.

Abbreviations	***Meaning***	***Page***
NCAA	National Collegiate Athletic Association	1
NBA	National Basketball Association	1
ENREB	Education/Nursing Research Ethics Board	45
MEMS	Microelectromechanical Systems	49
FIBA	International Basketball Federation	50
ANOVA	Analysis of Variance	57
SPSS	Statistical Package for the Social Sciences	58
LSD	Least Significant Difference	58
Q-Q Plot	Quantile-Quantile Plot	58
SD	Standard Deviation	60
n	Number of Subjects	60
df	Degrees of Freedom	62
IQR	Interquartile Range	64
CMU	Canadian Mennonite University	136

GLOSSARY

The following terms are defined in the context of this thesis. Secondary research is used, when necessary, to help define the terms.

	Basketball Terms
Back Spin	A spinning motion given to a ball that causes it to rotate backwards.
Catch and Shoot	Shooting the ball immediately after receiving a pass.
"Dip"	The motion of lowering the basketball from a player's shooting pocket to set the shooting motion.
Fade Away Shot	Jumping away from the hoop while shooting the ball.
Jump Shot	Shooting the ball while in the process of jumping.
Off the Dribble	Shooting the ball after dribbling it in some direction.
Off the Screen	Using a teammate to get open and shooting the ball.
"Rhythm"	The ability to combine the upper and lower body movements into one smooth motion.
Set Position	Position of the body and ball once the "dip" has finished.
"Shooter's Touch"	The ability to make shots regardless of how the ball hits the rim.
Shooting Pocket	The area of the body when all parts of the shooting arm are in a vertical plane out in front of the shoulder, holding onto the ball.
Side Spin	A spinning motion given to a ball that causes it to rotate on its vertical axis.
"Turn"	Shooter turning in the air in order to lead with his shooting shoulder.
	Optic Information Terms
Centre of Pressure	The concentrated point where the pressure of the body rests over the soles of one's feet.
Foveal Point	The area responsible for sharp central vision.
Gaze Behaviour	"The gaze held stable on a location in the environment or a shift in gaze from one location to another" (Vickers & Adolphe, 1997).
Optic Array	"The pattern light makes as it strikes the retina of the observer" (Kennedy, 2015, p. 3).
Optic Flow	"The continuous change that occurs in the optic array due to movement of the eye or objects in the environment" (Kennedy, 2015, p. 3).
Postural Sway	Changes in the location of centre of pressure.
Quiet Eye	Gaze behaviour immediately before movement in aiming tasks.

Retinal Defocus	Blurred vision.
Saccade	The rapid movement of the eyes to a fixation point.
Visual Acuity	Sharpness of vision.
Laterality Terms	
Distractors	Objects that influence attention.
Extrapersonal Space	The space outside the person's reach.
Global Processing	Perception of unique groups as one singular object.
Lateral Bias	A deviation in movement because of a distractor.
Local Processing	Perception of distinct groups.
Peripersonal Space	The space immediately around the person's body.
Motor Learning and Behaviour Terms	
Effective Target Width	The variable error around a target location.
Especial Skill	A motor skill that exhibits a superior task performance in comparison to performances of others.
Fitts' Law	A predictive model of human movement, resulting in a speed-accuracy tradeoff.
Horizontal Virtual Target	The perceived target width based on the shooter's location on the floor.
Impulse Variability Theory	"Increases in the variability of targeted motor responses resulted from the enhancement of peripheral neuromuscular noise" (Slifkin & Newell, 1999, p. 837).
Index of Difficulty	The value of human performance within tasks.
Noise	The random electrical firings which interfere with the movements.
Spatial Variability	A quantity that is measured at different locations exhibits values that differ across the locations.
Temporal Characteristics	The physical components of an action.
Biomechanical Elements Terms	
Extension	The straightening movement of one bone on other.
Flexion	The bending movement of one bone on other.
Proprioceptive Feedback	The awareness of joint positioning.
Sagittal Plane	The plane dividing the body anatomically left and right.
Visual Feedback	The attention towards an external cue in reference to a particular movement.
Fitness Terms	
Aerobic Energetic Processes	The use of oxygen in muscles' energy-generating process.
Anaerobic Energetic Processes	The process of quick resynthesizing of energy without using oxygen, used in short bursts of energy use.
Effort Character	Focusing on movement velocities in training rather than how much weight the athlete is lifting.
Physical and Mental Training Terms	
Mental Rehearsal	The practice of a task, without overt physical movement.
Self-Talk	The act of talking to one's self in order to make corrections in a task.

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DEDICATION

This thesis is dedicated to those who have enabled and encouraged me through my journey in life: my mother, father, brother and grandmother. Without these people, I would not be where I am today. They believed in me even when the world did not.

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Thank you all. Never forget how important you are to me.

Chapter 1

THE PROBLEM AND ITS BACKGROUND

1.1 Introduction

Dr. James Naismith invented basketball in 1891. According to National Collegiate Athletic Association (NCAA) Archives, it took almost forty years for John Miller Cooper to attempt the first jump shot in history (Pennington, 2011), and more than seventy years before coaches and athletes realized the shot was not going to ruin basketball, allowing it to be a fundamental part of the game (Fury, 2016). The attempt to curtail the use of the jump shot was a direct result of coaches and instructors teaching the game of basketball the way they thought it should be played and passing this ideology to the next generation of coaches, influencing the skills used within the game (Fury, 2016).

In recent years, one of the more polarizing skills within basketball was the “dip”, the motion of lowering the basketball—the back swing of the jump shot shooting motion—from a player's shooting pocket, defined as the position of the body when all parts of the shooting arm are in the vertical plane out in front of the shoulder to set the shooting motion (Hoover, 2014). Subsequently, this concept of “dipping” the basketball upon receiving a pass before shooting has been perceived negatively for several decades as it would be too easy to block (Hoover, 2014). However, when the principal investigator observed videos of the greatest National Basketball Association (NBA) shooters of all time it was noted that “dipping” is prevalent in most of their shots. As a result, the concept of the “dip” needs to be better understood by observing whether it improves the accuracy of one’s shot by directly comparing shot accuracy with and without the “dip”.

1.2 Identification of the Problem

Mike Penberthy, who played as a guard for the Los Angeles Lakers and now works as a trainer in Southern California, stated his displeasure publicly about teaching the “dip” to younger athletes (Hoover, 2014); however, he himself “dipped” when he shot. According to Murphy (2015, April), sharpshooters like Klay Thompson of the Golden State Warriors utilized the “dip” to decrease the possibility of an angular release, or a lateral movement away from the desirable shot path plane (Okubo and Hubbard, 2015). In many cases, shooters like Thompson did not receive the ball exactly where they wanted to rise up with it to shoot. Without the “dip”, an awkward lift would be created towards his release point. Murphy (2015, April) believed that Thompson’s goal was to ensure the same shooting motion every time he took a jump shot by “dipping” the ball to the same starting point. From a shooter’s perspective, the minimization of extraneous movement helped prevent the need for adjustment to the pass. Another related question was whether there was a distinct location on the basketball court that marked an increase in shooting accuracy while using the “dip”.

By conducting research on the “dip”, the purpose of the present study was to assess shot accuracy with and without using the “dip” at game-specific shot distances. It was predicted that besides the ability for a shooter to utilize the “dip” as quickly as possible to reduce the effect of defenders, the “dip” should also improve one’s accuracy through the resetting of the shooting motion through performing the same set of movements each shot. The “dip” should reduce the number of variables when performing a jump shot by allowing the shooter to use the same biomechanical movements each time the player shoots a basketball.

1.3 The Jump Shot

Understanding and dissecting the jump shot is a difficult task because there are so many variations to a particular situation, ranging from catch and shoot, off the dribble, off a screen, and contested by a defender (K. Schepp, personal communication, November 29, 2017). As a result, one must understand the different components that can affect the success of a jump shot, such as optic information, laterality, motor learning and behaviour, biomechanical elements, fitness, and physical and mental training. Focusing on whether the “dip” will or will not improve the accuracy of the jump shot should add to the knowledge of biomechanics related to shooting a basketball. The catch and shoot scenario was chosen as the basis for the study because it allowed for the most control within the laboratory setting, but also provides a foundation to build on for future studies. In the other scenarios, such as off the dribble, shooting after dribbling the ball, or off the screen, running around a teammate’s body to get open, dribbling acts as a natural “dip”, so all players would be considered “dippers” in this case. Whereas, in the catch and shoot, the natural form of the player is more prevalent, allowing for a variety of shooting motions. Narrowing the study to a specific scenario for shooting allowed for a more controlled setting, in order to assess the impact of one component, the “dip”, and understanding other factors, like motor learning and behaviour, will help provide a well-rounded answer to the proposed research questions.

Chapter 2

LITERATURE REVIEW

2.1 Research Gap

2.1.1 The "Dip"

The "dip" is the movement of lowering the ball below a player's shooting pocket. By lowering the ball, the shooting fingers will leave the vertical plane, initiating the "dip". This movement has become a controversial concept in the basketball industry with no firm scientific evidence to support if there is a cost or benefit to the dip. Subsequently, anecdotal evidence and case studies of individual players were the only sources of information for the "dip" beyond coaches' opinions of whether the "dip" works or does not work. For example, Brad Stevens, the current coach of the Boston Celtics, said when referring to the jump shot of Marcus Smart, "We don't have any sample size yet, but I think, at the end of the day, he has worked on it. He's put in a lot of time to make it more fluid" (Weiss, 2016). Stevens' statement was referring to Smart's adjustment with his "dip". Furthermore, NBA shooting coach Chip Engelland, nicknamed the "Shot Doctor", has reconstructed many players' shots. In a clinic addressing other coaches, he said, "If you need to dip for rhythm, that's ok. You shouldn't rush 3-pointers. If you needed to rush it, that just tells you that you should have driven it or passed it" (Engelland, 2015). These are examples of evidence that the "dip" is supported within the coaching community, but to my knowledge no scientific research has been done. As a result, a gap was seen in the scientific literature, trying to connect the "dip" to the field of basketball coaching. No scientific research has been done on the "dip" to the knowledge of the principal investigator, resulting in other coaches opinions being the main support for the "dip". The present study will attempt to bridge the gap and create a foundation for future research in the area of the “dip” by adding a scientific approach for others to follow.

2.2 Optic Information

2.2.1 Gaze Behaviour and the Quiet Eye

The game of basketball requires a player to perform spatially-demanding tasks as he moves around the court, resulting in vision being of particular importance in order to score baskets. Vickers (1996) described gaze behaviour as the way people utilize the head and eyes to observe the environment, using the information to better set up and complete different tasks, such as a jump shot. Vickers (1996) reported that elite players responded differently in using these eye movements during free throws compared with near-expert shooters (Vickers, 1996). Expert free throw shooters focused for a longer time on the basket, moved the head less, as well as made fewer fixations with the eyes prior to the shot being released (Vickers, 1996). Furthermore, the research showed that shooting success relied on efficiency, in terms of less head movement and fewer visual fixations. In other words, it can be argued that the athlete maintained his attention on the basket. This focus on the target enabled the athlete’s visual input to be accurate and consistent (Ripoll, Bard, & Paillard, 1986).

However, as seen in the work of Carlton (1981), the point at which fixation occurred greatly affected accuracy of the task. When looking at Italian labourers using hammers to strike stones, Woodworth (1899) was the first to show that vision appeared to be used to control the movement only when the striking object was close to the target, the ending part of the motor response movement. In a basketball context, visual acuity changed as the hand approached the net, resulting in the hand shifting into a different visual field (Carlton, 1981). Furthermore, Carlton (1981) surmised from this that as the hand moved closer to a target, the accuracy of the visual feedback would improve. The accuracy would also be supplemented by the hand moving closer to the area of the eye responsible for sharp central vision, the foveal point, which would be important for tasks relying on vision, perhaps like shooting a basketball (Carlton, 1981).

The last visual focusing, prior to initiating the final movements of the shot, was called "quiet eye", and experts appeared to utilize this more effectively than less experienced players (Vickers, 1996). Higher levels of skill and accuracy in sport had longer "quiet eye" duration (Oudejans et al., 2005). Vickers, Rodrigues, and Edworthy (2000) demonstrated that the accuracy of a task was influenced by the onset of "quiet eye", the final part of the action, and offset, the initial part of the action, of "quiet eye". Their work suggested that longer "quiet eye" periods were conducive to accuracy. Vickers, Rodrigues, and Edworthy (2000) asked participants to throw darts at a dartboard. The authors observed that hits resulted in gaze being off the target for 550 milliseconds, a shorter period than misses; if the throw was offset while in the middle of the process of throwing then the focus was not on the target for 1167 milliseconds, resulting in a miss. In other words, a hit was associated with the gaze being off the target for less time. These findings supported the research done by Abrams, Meyer, and Kornblum (1990), in which it was found that the players corrected their wrist movement as a result of looking at the position of the arm and hand. A training study found that the training of this "quiet eye", through basketball preseason feedback sessions and that were reinforced during the season, led to a more efficient and coordinated free throw routine (Harle & Vickers, 2001), indicated by longer "quiet eye" duration, and more stable "quiet eye" (Vine & Wilson, 2011).

2.2.2 Imposed Global Optic Flow

According to Gibson (1966), optic array was defined as the pattern of light reaching the eye while optic flow refers to the continuous change that occurred in the optic array as a result of shifting position of the orbit observing things in the surrounding area respectively. When the optic array changed, global flow was experienced by the observer. This experience was created by the movement of a player’s eyes through the environment (Tresilian, 2012). However, in sports like basketball where set shots occur, humans are sensitive to distractions that move as one, such as a crowd waving their hands together in the same directions, because they were tricked into experiencing sensations of movement, even though the athletes were still (Kennedy, & Berg, 2016). This concept was termed “imposed optic flow”. Within basketball, a continuous optic flow may give the athlete an incorrect sense that he was moving within the environment; for example, when fans of the opposing team wave coloured objects in unison while a player shoots a free throw or a jump shot.

When shooting a basketball, stability was an important component in the accuracy of the shot. Global imposed optic flow influenced the shooter’s perception of self-motion, causing a significant impact on “postural sway”, or the changes in the location of centre of pressure. According to Prieto and colleagues (1996), centre of pressure referred to the concentrated point where the pressure of the body rested over the soles of one’s feet. Some postural sway was nearly always present, and occurred naturally (Tresilian, 2012); however, excess sway was indicative of postural instability (Lee & Lishman, 1975; Prieto et al., 1996). Within basketball and shooting, postural sway became a major influence when fans behind a backboard created imposed global optic flow. The players may have experienced postural instability and lost a level of accuracy as a shot was attempted. Slate magazine writer Daniel Engber (2005) suggested that synchronized movement in the area behind the backboard, or “imposed global optic flow”, would decrease free throw accuracy because of the negative effects on stability. Conversely, Kennedy and Berg (2016) determined that accuracy of free throws was not majorly influenced by postural sway; however, this study was done in a laboratory, and not during actual games. As a result, these findings must be analyzed critically, and applied to real life games to see whether Engber’s theory or Kennedy’s findings, will be observed. In Whitney and colleagues (2003) research, they discovered in a near-aiming task, like reaching for an object, that a synchronized motion could distract the participant’s reach, causing the hand trajectory to change in the direction of the background motion. Therefore, if a player’s shooting motion was affected by the optic flow, accuracy would decrease due to biomechanical factors, through movement of the torso and the associated adjustments including hip extension and knee flexion (Oddsson, 1988). Ultimately, imposed global optic flow had an impact on shooting accuracy, to varying degrees, through postural sway, and altered shooting motions (Kennedy, 2015).

2.2.3 Retinal Defocus and Peripheral Vision

Visual acuity and peripheral vision play an important role in sensorimotor tasks associated with movement behaviour and overall athletic performance in fast paced sports that require precision (Oudejans, Langenberg, & Hutter, 2002; Oliveira, Oudejans, & Beek, 2006; Ryu et al., 2015). According to Ryu and colleagues (2014), experts may have had a superior ability to shoot because of their ability to pick up information using their visual periphery. They were better able to address central vision task requirements and, as a result, adequately assess information in their peripheral vision, whereas less skilled shooters tended to guess when using peripheral vision (Ryu et al., 2013). The experts’ ability to utilize central vision successfully allowed them to further analyze information in their periphery adequately (Weltman & Egstrom, 1966). Conversely, non-experts may have had to pay more attention to unfamiliar information in their central vision, resulting in little attention being paid to the peripheral information (Parker, 1981). Bulson and colleagues (2015) discovered that small to moderate amounts of nearsighted blurred vision, also known as “spherical myopic retinal defocus”, had not negatively affected shooters’ performance when taking free throw shots. However, it was likely that the free throw shot was less likely to be affected by blurred vision than a dynamic, interactive basketball jump shot in live competition due to the reduced number of variables such as the adjustment/adaptation needed in an increased release height from jumping. When looking at the concept of central and peripheral vision, and retina defocus, the optimal visual information experience must be determined.

An investigation by Oudejans, Langenberg and Hutter (2002) was done to determine the role of “early vision”, vision that was clear up to 350 milliseconds before ball release, and “late vision”, vision that was blocked until 350 milliseconds before ball release. Experimentally, the “early vision” condition was created so the participant experienced clear vision until the shooting motion was started, while the “late vision” was created by not allowing clear vision until the shooting motion was started. In this study, “early vision” shooters did significantly poorer than the baseline condition of full vision, while “late vision” shooters had no decline in performance. “Late vision” therefore, experienced a certain level of retinal defocus, or blurred vision, and still maintained performance (Applegate & Applegate, 1992; Ryu et al., 2015). According to Jackson and colleagues (2009), the moderate blurring of vision may have made the performance of such perceptual tasks easier. Practically, in “late vision” shooters, the distraction of an opponent, for example, could be limited as the player would not take in more visual information than was necessary to complete the task. In Ryu and colleagues (2015) research, the conditions in which peripheral blur increased accuracy of the shot when compared with the clear vision control condition, suggested that distraction levels had limited impact. Blurring was used to control peripheral information, to varying degrees depending on skill level, and helped reduce distractions to enhance focus on the central vision (Ryu et al., 2015). Ultimately, this research shows that the reduced distractions influenced the quality of the information taken in by the athlete, as well as the importance of the visual information as the athlete initiated the shooting motion.

2.3 Laterality

2.3.1 Lateral Bias

In general, objects or situations that influenced one's movement strategies directed towards a target were called "distractors" (Viggiano et al., 2014). According to Baumeister and Showers (1986), having an audience present, or the noise associated with an audience, had a negative impact on a player's shooting performance. When compared to a situation without any opponents, a defender who was trying to block the ball influenced the shooter to take a shot more quickly and to increase the vertical height of release (Rojas et al., 2000). Players could also be influenced by other distractors in what was called "lateral bias", a deviation away from a distractor (Viggiano et al., 2014). In other non-sporting research, it was demonstrated that determining the middle of a paper was significantly influenced by other objects on the paper, only if they were asymmetrical (Viggiano et al., 2014). The lateral bias was observed to be toward the opposite side from where the distractor was located; for example, the bias would be to the left if there were objects placed on the right (Fischer, 1994; Chieffi, 1996; Chieffi & Ricci, 2002). This kind of "perceptual distractor" (Viggiano et al., 2014) also created an alteration in the direction of movement of the extremity when sketching a line in the direction of a position surrounded by distractors, or when trying to pick up something (Chieffi, Ricci, & Carlomagno, 2001; Chieffi et al., 1993).

In a basketball context, the presence of a defender guarding a shooter would represent a perceptual distractor when standing on either side of the basket in the visual field. However, the position of the defender, rather than just the presence, could be a distractor for a basketball player; for example, when trying to take a jump shot (Viggiano et al., 2014). In Viggiano and colleagues' (2014) study, each player would take 80 jump shots, 20 at each experimental condition. The experimental conditions included a defender with outstretched arms at three spots, and a fourth with the defender out of view. In this experiment, the shooter was always aware of the presence of the defender; as a result, the deviation in the shots experienced would not be attributed to a surprised reaction of the defender being there. The experimental conditions with the defender on the right or the left resulted in -5.80 cm and 4.30 cm deviations respectively, demonstrating a positioning effect, caused by the defender, on the shooter (Viggiano et al., 2014).

Shuren and colleagues' (1997) research on the "centre of mass effect" and Tipper and Howard's (1997) research on the "lateral inhibition theory" represent two hypotheses that attempted to explain how the defender affected the accuracy of the attempted basket. Viggiano and colleagues (2014) investigated the potential cause of lateral bias by testing the two aforementioned hypotheses in a basketball context. Within the experiment, when the defender was placed laterally, he created asymmetry within the shooter's vision, resulting in an alteration because the shooter had a harder time identifying the exact location of the basket. According to the “centre of mass effect”, since the opponent guarding the shooter was laterally placed, the asymmetry caused the shooter to misjudge where the actual centre of the basket was located, to one side or the other, and this was dependent on where the defender was placed (Viggiano et al., 2014). Conversely, the defender unconsciously was seen by the shooter as a distractor, even if the shooter knew the defender could not block or alter the shot. According to the “lateral inhibition theory”, this unconscious thought can cause the shooter to want to use a different movement strategy, specifically one to avoid the defender the shooter observed, which will attempt to override the primary movements, thus, causing a change in the path of the shot (Tipper, Howard, & Houghton, 1998). These hypotheses help understand the concepts behind lateral bias and how to control for it in a research design, in particular, camera and passer positioning for the present study.

2.3.2 Centre of mass effect

In “line bisection tasks”, as studied by Shuren, Jacobs, and Heilman (1997), the goal was for the participant to draw a line that divided the paper into two equal parts. It was noticed that attention influenced estimates within these types of tasks. When bisecting a line, a person had a bias toward the side in which he directed more attention; for example, if attention was focused on one side of the paper, the line will be bisected closer to that side (Milner, Brechman, & Pagliarini, 1992). In normal circumstances, the focus would be the spatial position one was occupying; for example, focusing on the hand and pencil as a line was being drawn. According to Coren and Hoenig (1972), subjects were influenced by non-targets within the “center of mass” of a group of objects. For example, a person will “saccade”, rapidly move their eyes to a fixation point, beyond the target if there are objects beyond it, and he will saccade before the target if there are objects between him and the target. Paying attention to “centre of mass” activity depended on one’s proclivity to look at groups as a singular object (Shuren, Jacobs, & Heilman, 1997).

The “centre of mass effect” had an impact on players such that if they were better at perceiving a group as one singular object, known as “global processing”, then the effect would be small (Shuren, Jacobs, & Heilman, 1997). Conversely, if he was better at perceiving distinct groups, known as “local processing”, then the lateral bias effect would be larger (Shuren, Jacobs, & Heilman, 1997). In these tasks, the visual field was important to recognize as encompassing the whole area that objects can be visualized when focusing on a central point. Using this definition, the lower visual field is where an object can be visualized below this central point and the upper visual field is where an object can be seen above this central point. Previc (1990) suggested that one’s lower visual fields were more important for interpreting information from the outside world for eye-hand coordination tasks in “peripersonal space”, the space immediately around the person’s body, while one’s upper visual fields were more important for looking at the “extrapersonal space”, the space outside the person’s reach, in seeing and recognizing actions. As a result, with respect to tasks done in the sagittal plane, the plane dividing the body anatomically left and right, the “centre of mass effect” would be greater when the division between objects occurred in the upper visual field because the distinction of the objects as individuals, rather than as a single object, is more easily achieved in the upper visual field (Shuren, Jacobs, & Heilman, 1997).

In a basketball context, global processing in the lower visual field was necessary to perceive blurred images in near vision, such as the basketball in a player’s hands or a defender’s hands; whereas images in far vision, such as the basketball net or a jumping defender, should be perceived through local processing of distinct objects (Shuren, Jacobs, & Heilman, 1997). The defender would be in the upper visual field of a shooter. Therefore, the shooter must attempt to process everything as a single entity because the allocentric, or object-centred, references as well as the "extrapersonal space", are most effective in the upper visual field (Zhou et al., 2017). For a research design, one could reduce the asymmetry of the overall scene for the shooter by placing the camera or passers on either side of the basket, thereby reducing the "centre of mass effect".

2.3.3 Lateral inhibition theory

In selective reaching tasks, where participants were required to reach for specific targets, such as a full coffee mug among several empty ones, the distractors, being the empty mugs, were seen as something to avoid, resulting in negating the distractors while the subject located the target, being the full mug (Howard & Tipper, 1997). In Howard and Tipper's study (1997), the participants were asked to focus on the central cue, a light-emitting diode of a specific colour. Then they were supposed to reach quickly for the same coloured diode on the table. By scanning the table for the same coloured diode, the participant was filtering out all other colours, or distractors. Interference of the reaching path occurred leading to a change in direction of the limb. The connection with the initial location of the hand and the placement of the distractors determined the levels of interference experienced and the amount of blocking needed to successfully complete the task (Shuren, Jacobs, & Heilman, 1997). This information suggested that distractors in closest proximity to the hand caused the most interference and caused more deviation as a result, when compared to distractors further away from the hand (Howard & Tipper, 1997). For example, when reaching for the mug of coffee, if there were many empty mugs nearer to the hand, the person will experience more interference from them, making the process slower than if the mugs were further away.

Research done by Sheliga and colleagues (1994; 1995), in activities using saccadic eye movements, demonstrated that when people observed a cue around a fixation, subjects had saccadic activity that was seen above or below fixation. A second experiment done by Howard and Tipper (1997) was done to demonstrate the inhibition effects within saccade tasks. In this experiment, the cue was moved from the front, as in the aforementioned experiment, to the centre of the table. Since the location of the target was unpredictable, participants' fixation occurred in the centre. As a result, the deviation effects were more evident in the vertical plane when compared to the horizontal plane as the saccades deviated away from the cue (Howard & Tipper, 1997). For example, if the cue had been on the top, saccades moved to the bottom. When the task required detecting moving objects, such as basketballs, the hand became the centre point of object-based frames of reference. These frames were always moving, resulting in the inhibition moving as well (Tipper, Howard, & Houghton, 1998). Tipper, Howard, and Houghton's (1998) work presented hand-eye coordination skills as action-based representations, continuously being processed, thus being useful for developing effective movement strategies. The ability to select effective movement strategies was seen as a way to prevent selecting the primary strategy all the time (Tipper, Howard, & Houghton, 1998).

In a basketball context, selective reaching tasks could relate to catching the ball to shoot. Saccade tasks could relate to shooting with a defender guarding the shooter. The "lateral inhibition theory" illustrates why the shooting motion towards the basket may cause the shooting path of the ball to deviate. Once understanding why this happens, strategies could be used to make these movements more efficient. Resetting the shooting motion may provide more consistency.

2.4 Motor Learning and Behaviour

2.4.1 Fitts' Law

The basketball jump shot is an ability that requires speed and accuracy in the performance of the movement (Okazaki & Rodacki, 2012). Fitts' Law (see equation 1) was used to illustrate the speed-accuracy tradeoff where the movement time *MT* to a target was a logarithmic function of the distance to the target *A* and the width of the target *W* expressed as

$$\boxed{MT = a + b * log_2 \left(\frac{2A}{W}\right)} \qquad (1)$$

Fitts' Law

where *a* and *b* are statistically determined constants found using the movement data (Fitts, 1954). This speed-accuracy tradeoff illustrated that with a perceptually wider basket hoop, due to a closer distance, it was possible to change position more rapidly and maintain accuracy. However, as distance between the target and the shooter increased, it took longer to move to the target.

Decety and Jeannerod (1996) demonstrated that Fitts' Law was applicable to movements that were imagined, by testing participants using virtual reality and running through gates on a track. For example, when an athlete used mental rehearsal techniques, the parameters of the shooting motions and physical laws were maintained. There was also evidence that when preparing for future movements, like a jump shot, the shooter had implicit knowledge of Fitts' Law, in which visual constraints and the difficulty of planned movements were understood.

(Augustyn & Rosenbaum, 2005). Based on Fitts' Law, the index of difficulty (*ID*, see equation 2)

$$ID = log_2 \left(\frac{2A}{W}\right) \tag{2}$$

Index of Difficulty

is one component of the metric for human performance within tasks. As a result, it is possible to have different target widths and target distances, but yield the same movement time (Eskenazi et al., 2009). For example, a target distance of 8 centimetres and a target width of 2 centimetres would yield the same index of difficulty as a target distance of 32 centimetres and a target width of 8 centimetres.

Additionally, Crossman (1956) proposed an adjustment to Fitts' Law (see equation 3) in which the target width was replaced with the effective target width, the variable error around a target location, in a new equation

$$ID_e = log_2 \left(\frac{2A}{W_e}\right) \tag{3}$$

Crossman's Adjustment to Fitts' Law

resulting in the index of performance (*IP*, see equation 4) being represented by

$$IP = \left(\frac{ID_e}{MT}\right) \tag{4}$$

Index of Performance

where its calculation provided insight into different spatial locations exhibiting different values across those locations because it takes into account the effective target width. In a basketball context, spatial variability is experienced by a shooter when he shoots from different distances on the court. As a result, while the size of the basket does not physically change, the perceived target width based on the shooter's location on the floor, the horizontal virtual target decreases as moves farther from the basket, resulting in a need for greater accuracy (Okazaki & Rodacki, 2012). For example, the virtual horizontal target is smaller when shooting from the three-point line in comparison to the free throw line, which would also result in a decreased effective target width at the three-point line. Lastly, if the shooting distance increases, then the force requirements to reach the basket increase, making the player take into account this task constraint (Okazaki & Rodacki, 2012). According to Fitts' Law, this concept would exhibit an inverse relationship between distance and accuracy, but in research done by Okazaki and colleagues (2007) and MacKenzie (1992), the perfect relationship did not exist. While Fitts' Law played a role in accuracy, especially if a shooter was taking shots from the same angle, the variability in the forces a player used during the shots represented a component not taken into account. This is because a player could not replicate exactly the same movements using exactly the same force each time.

2.4.2 Force-Variability

Within sports, athletic performance is judged through the consistency of the athlete to maintain accuracy of motor skill movements over time (Salonikidis et al., 2009). Expertise was seen as the ability of the athlete to reduce the amount of force-variability within sport-specific actions, resulting in more consistent movements. The variability in force could come from various aspects of the motor skill or the circumstances. For example, in basketball, if a player was being guarded by a defender, it could affect the visual feedback, as well as the specificity of the action and the muscle groups being used (Christou, 2005; Christou and Carlton, 2001). In a basketball scenario, a step-back jump shot, where the athlete must change direction of forces from forward to backward, would result in larger variability of force compared to a catch and shoot scenario, if the player were to take the shot multiple times. Scientifically, Schmidt and colleagues (1979) proposed the impulse variability theory (see equation 5).

$$\boxed{W_e = a + b^*\left(\frac{A}{MT}\right)} \quad (5)$$

Impulse Variability Theory

Impulse variability states that the variability of a motor response increases due to an increase in neuromuscular noise with increasing forces. Fitts' Law seemed to account for slower motor responses, but the aforementioned model appeared to be more effective than Fitts' Law for movements when movement times were less than 200 milliseconds due to the movement speed (Schmidt et al., 1979). This model was central to motor control theories in which movement outcome variability was reduced or dampened by a mechanism within the body's intrinsic neuromotor noise (Meyer et al., 1988; van Galen & de Jong, 1995).

According to Schmidt and Sherwood (1982) the variability in muscle generated forces was generally not related to the various muscle groups that contributed to a specific movement. For example, during a shooter's jump shot, one muscle, like the triceps, may produce too much force and another muscle, like the biceps, could produce not enough force. Furthermore, if all of the muscles contracted proportionally too much or too little on a jump shot, meaning muscles' variations were highly positively correlated, then a player would not experience a change in shot accuracy as the force of the shot would always be the same (Schmidt & Sherwood, 1982). According to Sherwood and colleagues (1988) variability of force increased as levels of force increased linearly, resulting in the variability in the force levels being viewed as noise, as defined by, random electrical firings which interfere with the movements.

Conversely, Sherwood and Schmidt (1980) hypothesized that it was unlikely that, over a person's force production spectrum, the interrelationship between force and the variability of the force would remain linear. They found an inverted-U relationship between peak force and peak force variability as a result of three experiments they conducted. During these experiments, the participant was required to grasp a lever with his hand, trying to get the dot within the oscilloscope to a certain point with no correction. In the second experiment, the participant was required to grasp the lever rhythmically, using a metronome, in a pulsating fashion. This experiment demonstrated that peak force variability increased linearly until it reached 65% of the participant's maximum force, but decreased once the forces exceeded this threshold (Sherwood and Schmidt, 1980).

Slifkin and Newell (1999) demonstrated that the level of noisiness exhibited an inverted U-shaped function over production of the force, resulting in force variability. This finding was felt to suggest, over the force production spectrum there was an area where information transfer, from visual information to physical movement, was most efficient, which influenced targeted force production (Slifkin and Newell, 1999; 2000). This area was also correlated with maximized noisiness, or complexity of the forces. It was demonstrated that accuracy variability, the level of accuracy at a specific spot, increased with distance and could be decreased by an increase of co-contraction, or limb stiffness (van Galen & de Jong, 1995). There must be increased contraction forces of the various muscles involved in a movement, which must be distributed across these muscles in a particular way, as the speed or mass of the object being moved, in addition to the weight of the limb, increased (Schmidt & Sherwood, 1982).

Through Schmidt and Sherwood's (1982) work, it was suggested that stability within the joints was important as force requirements increased. The muscles involved in each motor action helped increase the stability of the joints, suggesting that the muscles acted proportionally as force increased. For example, as a basketball is shot from farther away, the muscles involved remained proportionally used as the force necessary to get the ball to the basket increased. Force-variability Ultimately, understanding the stereotyped motions for various sports tasks and the variability of forces in those tasks will help reduce the negative effects on accuracy.

2.4.3 Analogy and Explicit Learning

As coaches and instructors, the challenge in teaching athletes and students relates to how the skills can be optimally learned. Implicit and explicit instructions have different methods in reaching the same goal. Research has attempted to understand under what circumstances each method is most beneficial. The concept of implicit motor learning is a passive process involving the acquisition of knowledge without awareness of what has been learned, and more importantly, is difficult to communicate to others from where the information is derived (Masters & Maxwell, 2004). Conversely, explicit motor learning is an active process allowing people to structure information presented to them, making huge demands on their working memory (Masters & Maxwell, 2004). Due to the differences in explicit and implicit instruction, it was important to determine which method helped with the learning of dynamic skills, like the jump shot.

According to Baddeley (1986), explicit motor learning, like a coach saying to the player, “pop your shoulder, and flick your wrist”, tended to overload a player’s working memory resources. This concept was demonstrated in Baddeley’s (1966) research in which participants were asked to recite a random sequence of letters while card sorting. The working memory was loaded, causing the secondary task, in this case, card sorting, to deteriorate in quality and ability (Baddeley, 1966). In Hardy and colleagues (2001) research, they used trampolinists in high stress and low stress circumstances with shadowing, the teacher being there to give cues, and no shadowing, without the coach, teaching conditions. The research showed that the trampolinists exhibited no change in low anxiety neither with shadowing, nor with high anxiety without shadowing conditions (Hardy et al., 2001). However, in the high stress condition when being observed, performance declined. The outcomes suggested that the technical points from the coach and high anxiety states encouraged conscious processing, interfering with the execution of a motor skill. The inference was that the motor skill, anxiety, and other factors, like adjusting to a defender, each took up attentional capacity, affecting cognitive resources (Hardy, Mullen, & Martin, 2001).

Conversely, when performed under pressure, a motor skill that was acquired implicitly avoided interference, was perceived as more automatic (Ezell, 2012), and had lowered attentional demands (Masters, 1992). In Masters' (1992) research, he had participants learn to putt a golf ball through implicit or explicit learning. The explicit learning group drew their instructions from two coaching golf books, while the implicit learning group had to recite random letter sequences, done to suppress explicit knowledge (Masters, 1992). Stress was placed on the participants in the last session by having a proclaimed expert watch them putt. As a result of the study, the implicit group showed no deterioration in task performance, while the explicit group did experience a decrease. Masters (1992) suggested that the implicit group's result was because they had less rules to process while putting the ball. By comparison, the explicit learning group had a checklist of points that the participants thought about each time they putted the ball, affecting their ability to complete the task efficiently.

Masters (2000) developed the concept of "analogy learning", cloaking many of the technical rules in a skill, as a way to promote acquisition through implicit motor learning. Movement analogies provided a metaphor which combined all the components of the skill into one, easy to understand image (Masters, 2000; Poolton, Masters, & Maxwell, 2006). In a basketball context, analogy learning may promote acquisition of task-specific knowledge implicitly with minimal impact on attentional resources. For example, the “cookie jar” analogy, in which a player extended his arm above his head and flicked his wrist, as if he were reaching into a cookie jar on the top shelf, in shooting a basketball could be seen as an alternative to explicit instructions. According to Lam and colleagues (2009b), it was found that analogy learners were equally as effective as instructed learners at learning new skills, while also maintaining performance during a secondary task. Analogies allowed for the athlete to create many movement patterns to complete a motor skill, accounting for variability within the action, whereas explicit learning suggested there was only one movement pattern available for completion (Komar et al., 2014). This finding showed that a checklist of movement skill components was not necessary to complete a motor task (Lam, Maxwell, & Masters, 2009b), like shooting. Instead, a single instruction using an analogy produced equivalent learning.

2.4.4 Especial Skills

Within most cognitive theories of motor learning there was debate about how motor skill representation was formed. Researchers investigated whether, within motor skills, there were singular or multiple movement patterns for each group (Breslin et al., 2010). These patterns, whether singular or multiple, represent a mental motor program. A generalized motor program view of behaviour does not account for a specialized or “especial” skill within a large motor skill class such as shooting a basketball (Keetch et al., 2005). An “especial skill” was the result of massive amounts of training, as well as being a motor skill that exhibited a superior task performance in comparison to performances of other similar tasks (Keetch et al., 2005). Within basketball, as a shooter moved closer to, or farther from, the basketball hoop there was a consistent change in the percentage of made shots, with accuracy decreasing linearly as the distance to the hoop increased. However, for skilled basketball players, the shooting percentage was significantly better than expected when the shooter shot set shots from the free throw line specifically (Keetch et al., 2005). The “especial skill” effect arose from the large amount of practice time coaches and athletes spent on this particular shot when compared to any other variant. At a general level, basketball players shot set shots at a general level of accuracy based on their experience and the difficulty of the shot; however, because the foul shot was special to the sport, the principle of specificity seemed to take precedence (Breslin et al., 2010).

According to Schmidt’s Schema theory (1975), there were two cognitive patterns stored in memory for motor skills: the generalized motor program, and the recall schema. The generalized motor program suggested that for each type of activity, like a jump shot, there were components that would never change, such as the order of the limb movements or the relative force and timing (Keetch et al., 2005). Conversely, the recall schema was responsible for providing adjustments to the generalized motor program based on the situation being experienced by a person (Keetch et al., 2005). For example, when an athlete was passed the ball, then taking a set shot fifteen feet from the basketball, the generalized motor program provided the basic ability to complete the shot, whereas the recall schema adjusted for defenders and teammate locations. According to Keetch and colleagues (2008), it was possible that these “especial skills”, while they appeared to be a similar variant to a class of motor skills, were actually a separate generalized motor program. This would be shown through different patterning when compared to other shot selections. Ultimately, if separate generalized motor programs existed, it could be surmised that the distance of the shot taken may not be the most important component, but other issues from practice or game situations that accumulated over time (Keetch et al., 2008).

2.4.5 Practice

How an athlete practiced a skill greatly determines his success in developing and retaining the skill. Shea and Morgan (1979) investigated two types of practice schedules: block, training a skill consecutively before moving onto a new one, and random, training skills together and in no predictable order. In the study, participants had to respond to a yellow warning light then complete a sequence of tasks. In this acquisition phase participants were given three sets of tasks either presented in a block practice style or a random practice style. The participants were then retested ten minutes after the trials, then ten days after the trials in the retention phase of the experiment. Under the various conditions, when random practice was provided in the acquisition phase, the results were worse than block practice, but the important part was that the performance markedly improved in the retention phase (Shea & Morgan, 1979).

An important distinction had to be made between block and random practice, and constant practice, completing a task under the same conditions, and variable practice, completing a task under a variety of conditions (Shoenfelt et al., 2002). Block and random practice referred to the practice schedule, while constant and variable practice referred to practice variability (Kaipa, Robb, & Jones, 2017). For example, constant practice would consist of a player shooting 50 free throws, while a variable practice would consist of a player shooting some free throws then taking some three-point shots ending with more free throws. In Schmidt's (1975) schema theory of motor learning, the recall schema was seen to be strengthened by variable practice because of the variety of versions within a task.

In research done by Kantak and colleagues (2010), participants were required to mimic a 60° forearm movement demonstrated on a computer screen. In the constant practice condition, participants completed the condition 120 times. Conversely, in the variable practice condition, participants completed the main condition 60 times and three other conditions, 30°, 45°, and 75° movements, twenty times each. The researchers suggested that variable practice participants had better performance from end of acquisition to retention, tested one day later. Within discrete skills, like shooting a basketball, these concepts remained important to understand in an effort to improve athlete performances.

2.5 Biomechanical Elements

2.5.1 Release Angle

In order for basketball players to shoot consistent jump shots, the athlete has to release the basketball at a specific angle in order to provide maximum distance. Miller and Bartlett (1996) performed an experiment, where they recruited participants of three positions—guards, forwards, and centres—to determine several components including the release angle. Two major concepts became evident: the angle of release ranged from 48° to 54°, depending on the distance and position, and the farther the shot, the closer it was to Brancazio's equation (see equation 6),

$$\boxed{\theta = 45^{\circ} + \frac{1}{2}\phi} \tag{6}$$

Brancazio's Equation

where θ and φ represented the release angle and inclination angle, the angle of the shooting hand from the front of the rim, respectively (Brancazio, 1984). This concept illustrated the angle requiring minimum release speed (Miller & Bartlett, 1996). For shorter distances, shooters, regardless of the position, utilized release angles that provided a steeper angle of entry into the basket, increasing the horizontal virtual target width, thus creating a greater margin for error (Miller & Bartlett, 1996). For longer distances, the minimum release speed, demonstrated by Brancazio's equation, became more important due to the distance increase being influenced by the shooter's increased shoulder flexion and elbow extension, thereby providing maximum range in the shot (Elliott, 1992; Miller & Bartlett, 1996). Other research being conducted by Hamilton and Reinschmidt (1997), used simulations of the free throw to better understand the importance of the release angle in shooting. Subsequently, the researchers came to the mathematical conclusion that, when air resistance was taken into account, 57° was the optimal release angle (Hamilton & Reinschmidt, 1997). However, in other articles, the release angle of certain players was determined to be around 36° (Çetin & Muratlı, 2014). There appeared to be a variety of optimal release angles as determined by researchers using different techniques. The difference between the angles could be attributed to the fact that results were based on a variety of situations such as theoretical model simulations (Hamilton & Reinschmidt, 1997), experienced shooters (Miller and Bartlett, 1996), and youth shooters (Çetin & Muratlı, 2014).

Despite the variability, the idea behind release angle remains relatively unchanged. This was consistent with the release angle influencing the angle of entry of the ball through the basket due to the direct relationship the release angle had with the horizontal virtual target (Okazaki, Rodacki, & Satern, 2015). Okazaki and colleagues (2015) demonstrated that the process by which a shooter organized the movement of his joints was what defined his movement pattern when attempting a jump shot. As a result, the athlete may have been equipped to attempt shots using many different release angles by decreasing or increasing shoulder flexion, influencing the release height and necessary release speed (Okazaki, Rodacki, & Satern, 2015). This was also evident through several articles in which the shooters attempted shots from various places on the court, reducing the release angles as the shooter got further from the hoop (Miller and Bartlett, 1996; Çetin & Muratlı, 2014; Beuoy, 2015). The concept of release angle was greatly influenced by shoulder flexion, as well as how far away one was from the hoop (Okazaki & Rodacki, 2012). By increasing the shoulder flexion, a shooter could increase release height to reduce the necessary release angle, creating the "shooter's touch", or the ability to make shots regardless of how the ball hits the rim (Fontanella, 2006). The release angle used was significant in the biomechanics of the optimal jump shot, linked closely with release height, release velocity, and segmental body coordination (Okazaki, Rodacki, & Satern, 2015).

2.5.2 Segmental Body Coordination

How the body moves greatly affects performance in sports activities, simply because certain tasks cannot be performed if the different limbs act out of synchronicity. For example, in the case of the jump shot, shoulder flexion must occur before elbow extension; otherwise the basketball will never get above the rim (Knudson, 1993). According to Hudson (1982), increasing shoulder flexion and having greater elbow extension enhanced a player's ability to complete a successful jump shot. Much of the force and ability to shoot from long distances was generated from the extension of the elbow and flexion of the shoulder (Miller and Bartlett, 1993). Yates and Holt (1982) found out that five variables were responsible for most of variation in successful shots, the two most significant variables, in order of importance were larger shoulder flexion angles while shooting the ball and the starting angle of the elbow. When looking at precision, Stankovic and colleagues (2006) video recorded professional basketball players from KK Zdravlje in Leskovac, Serbia taking free throws until they reached ten misses, categorizing the shots as successful, underthrow successful, overthrow successful, and miss.

They found that the angle of the elbow joint was significantly different between successful and unsuccessful shots (Stankovic et al., 2006), illustrating that the coordination of movements in addition to consistency within those movements were important for a successful shot.

If a player continually changed the angles of the shoulder and elbow while shooting, accuracy and consistency of the jump shot would be decreased compared to an athlete that exhibited more consistent movement patterns. Ultimately, the movements of shooting arm, including the setting of the ball above the shoulder, extension of the elbow and the flick of the wrist, needed to occur in one plane of motion, in this case, the sagittal plane, resulting in the alignment of the shoulder and elbow with the hoop (Okazaki and Rodacki, 2015). Furthermore, while the shooting techniques of different basketball players seemed similar, the differences were significant enough to suggest that each player could be determined to have a unique shooting style (Struzik, Pietraszewski, & Zawadzki). These observations were due to different length proportions of the upper body segments (Kornecki, Lenart, & Siemieński, 2002). As a result, because there were many effective movement strategies in skilled shooters, such as increased range of motion in the shoulder and wrist, the ability to combine the upper and lower body movements into one smooth motion, or the “rhythm” of the shooter, would increase accuracy (Knudson, 1993). These findings may also be related to teaching points made by shooting coaches (Knudson, 1993). Subsequently, if the coordination of the shoulder flexion and elbow extension was done properly, then the release height of the ball would be increased, thus reducing the minimum release angle and optimizing the accuracy of the jump shot.

2.5.3 Release Velocity

As shooting distance increased, instinctively the necessary release velocity of the ball to reach the basket needed to increase, proving to be important when analyzing the biomechanics of a shooter. According to Miller and Bartlett (1996), the angular velocities of the upper limbs of the shooters resulted in a large increase in release velocity when distance was increased, except for athletes playing the centre position which the researchers hypothesized was as a result of the unfamiliarity of farther shots for these athletes. Intuitively, a greater velocity was required for farther distances because of the speed-accuracy tradeoffs, as demonstrated by Fitts' Law (Okazaki, Rodacki, & Satern, 2015). However, in expert players, greater movement accuracy, and by association a reduction in movement variability, was observed due to the movement strategy of reducing release velocities (Okazaki, Rodacki, & Satern, 2015).

Low release velocity was seen as effective because it allowed players to make necessary adjustments to their shot form, unless a player was unable to shoot the ball successfully to the basket in the first place (Okazaki, Rodacki, & Satern, 2015). These corrections were done using "visual feedback", where the athlete was located on the court, and "proprioceptive feedback", the awareness of joint positioning (Okazaki, Rodacki, & Satern, 2015), which could be achieved through practice (Schmidt et al., 1979). Since the athletes were able to internalize the feedback, it naturally reduced neural noise (Okazaki, Rodacki, & Satern, 2015). Weaker players struggled with the jump shot since many of these players were unable to generate sufficient force or had to generate more release velocity due to a shorter release height.

Hamilton and Reinschmidt (1997) used a theoretical approach to the issues for the weaker player, determining that, with the right combination of release velocity and release angle of a shot where the ball hit the back rim when compared to the front rim, was more accurate. As a result, players began to make adjustments for reducing release velocity, but also aiming for the back of the rim to counteract the extra velocity that was required. Athletes used the flick of the wrist as another strategy to reduce release velocity because the applied spin on the ball caused an increase in ball rotations during the shot (Okazaki, Rodacki, & Satern, 2015). According to Hamilton and Reinschmidt (1997) and Knudson (1993), applying back spin on the ball rotation reduced ball speed when it hit the rim or backboard, which reduced a lot of shooting error and resulted in a favourable bounce, redirecting the ball towards the centre of the rim. Also, within a shooter's form, if the shooting hand's elbow deviated to the side, the shooting arm likely would not be able to maintain an optimal position facing the basket, causing side spin, instead of back spin, to be applied to the ball when it was released (Okazaki, Rodacki, & Satern, 2015). This side spin would affect the release velocity negatively. However, to improve the accuracy of a jump shot, one must reduce release velocity, despite the negative influences, because of the advantageous nature of the slower speed. The release velocity appeared to be the easiest biomechanical element to influence, through alignment, stability, and distance.

2.5.4 Release Height

The release height of the ball determined the horizontal distance of the shot, influencing both the necessary release angle and release velocity. This premise thereby affected the success or failure of the jump shot (Satern, 1993). The outcome was directly related to release height; however, according to Miller and Bartlett (1996), the subject's height accounted for a maximum of only 35% of the variance. However, Brancazio (1984) suggested that by adding two feet to the height at which a shot leaves the player's hand increased the accuracy by 17%. Subsequently, the assumption would be that centres, and other taller players, would have the optimal release height since these athletes were typically very tall. In actuality, the research showed that centres had a negative value with respect to take-off, demonstrating that they preferred to shoot with both their feet maintaining contact with the floor (Miller & Bartlett, 1996). This preference was most likely the case because the centres chose to use forward and upward momentum of the body to increase release speed, as they were not used to generating the necessary release speeds for farther distances from the hoop (Miller & Bartlett, 1996).

Much of the research suggested that the minimum release speed was the ideal condition for a jump shot, and the way a shooter made this occur was by increasing his release height (Miller & Bartlett, 1996). The release height was pivotal to the success of the shot, and any way of reducing release height was considered to be a poor condition, such as a defender altering the shot or even a “fade away shot”, a shot where the shooter jumped away from the basket. Furthermore, shots taken from a farther distance from the basket presented a reduced release height and demanded that the athlete apply greater amounts of force to get the ball all the way to the basket (Okazaki & Rodacki, 2012). For example, a greater amount of force and reduced release height would be seen at the three-point line, when compared to the free throw line. These two components of a reduced release height and greater force resulted in less accurate shots (Okazaki & Rodacki, 2012). To optimize this concept, the ball would be released at the height of one’s jump (Knudson, 1993). According to Tran and Silverberg (2008), the probability of a successful shot was increased by about 5% with each 0.152m increase in release height above 1.981m.

In general, players should release the ball at the peak height of the jump shot because of the increased height and increased stability, due to the player’s vertical velocity, at that point in the jump, being zero (Elliott, 1992; Knudson, 1993). Within the literature, it was demonstrated that a shooter's release of the ball often occurred slightly before the peak of the jump (Elliott, 1992; Rojas et al., 2000). Consequently, releasing the ball before the highest point of a player's jump may have allowed the player to take parts of the vertical velocity generated and use it to create larger forces on the ball as it was being released (Okazaki, Rodacki, & Satern, 2015). The research demonstrated that there was a point where the maximum release height achieved lost importance because of the necessary forces needed to shoot a ball from far distances; however, within most realistic shots, for example not taking regular full court shots, utilizing the greatest release height possible, increased accuracy. Ultimately, increasing a player's release height helped reduce the necessary release angle and release velocity to allow the basketball to enter the hoop, but also allowed the player to use vertical velocity, generated from jumping, to increase his accuracy (Okazaki, Rodacki, & Satern, 2015).

2.6 Fitness

2.6.1 Fatigue

Basketball involves both aerobic and anaerobic energetic processes (Narazaki et al., 2009). To improve one's shooting percentage, players need to be able to shoot accurately while under different physiological pressures and during every phase of the game. According to Pojskić and colleagues (2014), if one used dynamic and competitive shooting drills, a positive outcome in regular basketball shooting was achieved. For example, drills like the dynamic 60-second three-point shooting test demonstrated that if a player was accurate during the test, then often they would be more accurate during a game (Pojskić et al., 2014). This result occurred because the sport required intermittent bursts of energy through vigorous activity, such as sprinting and shuffling. These same energy systems were being used in the aforementioned dynamic basketball drills making the information transferable. Coaches could utilize this information to help develop a player's shooting technique, while also identifying players who could cope with fatigue stresses.

Slawinski and colleagues used similar dynamic three-point shots and exhausting exercises to illustrate how the body responded to fatigue biomechanically. They found that fatigue caused a decrease in the angle of the hip joint, and an increase in the angle of the shoulder joint, resulting in an overall decrease in the player's range of motion (Slawinski et al., 2015). These results had been previously shown by Erčulj and Supej (2009) and Uygur and colleagues (2010); although both the aforementioned set of researchers also found that the jump height decreased in shots alongside the joint angles, due to fatigue. While the research did not find a statistically significant difference between a player's accuracy when fatigued or not, it represented the notion that a player would alter how he shot to compensate for the stress. More importantly, if this research was applied to a game situation, the results may show that the changes in form affected accuracy, namely release height. The wrist height, and subsequently the release height, was greatly affected by moderate-vigorous activity, a classification under which basketball falls (Erčulj & Supej, 2009).

These findings suggested that coaches needed to include more moderate-vigorous activity in their practices to help athletes preserve an appropriate shooting technique when fatigued, resulting in improved shooting accuracy. Moreover, Uygur and colleagues (2010), found that the elite athletes were capable of coping with fatigue when the action required less strength but more coordination, such as free throws. This finding demonstrated that fatigue affected explosive movements, like jump shooting, more prominently, thus making it more important to focus on this type of training instead. Ultimately, a coach must prioritize helping an athlete work on his shooting technique under physiological stress to improve his accuracy, thus helping make the transfer from a practice to a game.

2.6.2 Strength Training

People involved in sports have long promoted the positive effect of weight training. While weight training would not replace the skill related training, specific to the sport, the stronger the athlete, the better he could be within the sport. Masley, Hairabedian, and Donaldson (1953), put two groups, a volleyball class and a non-sports class, into a 6-week weight training program. They determined that an increase in strength resulted in increased muscular coordination and speed from the weight training when compared to merely doing physical activity alone. Furthermore, basketball required high levels of physical conditioning to allow players to exploit their technical and tactical skills throughout a game. Shoenfelt (1991) found that the weight training sessions happened before the training session for many teams, due to limited practice facility space. The athletes did not experience adverse effects from the sessions if they stretched prior to practice (Shoenfelt, 1991).

During training sessions, the most important stimulus seemed to be intensity when related to changes in strength level; assessment usually took place through the one maximum repetition (Schelling & Torres-Ronda, 2016). Subsequently, according to Izquierdo and colleagues (2002), strength training was performed using maximal loads through repetitions up to failure. However, training with repetitions up to failure may have been counterproductive in terms of power production, simply because it would put so much strain on the athletes physiologically, resulting in excessive fatigue and other strain as the muscles attempted to repair themselves (Schelling & Torres-Ronda, 2016).

According to Schelling and Torres-Ronda (2016), a better test for training prescription would be the "effort character", focusing on movement velocities in training rather than how much weight the athlete lifted. The main difference was that the "effort character" was based on movement-velocity and its loss, rather than maximum load (Schelling & Torres-Ronda, 2016). If trained properly a player should be able to increase his strength optimally. Coppedge (1967) observed that the improvement of strength resulting from weight training increased basketball shooting accuracy at 25 feet over a ten-week period by approximately two extra baskets out of ten shots. Ultimately, after training with weights the players anticipated rapid benefit on their shooting, but found a similar effect from aerobic exercise (Shoenfelt, 1991). The benefits from the weight training would be experienced if done safely and properly, not because of when the training occurred. Consequently, weight training should be seen as a way to positively impact a player's shot and accuracy, particularly from farther distances, but players must be patient with results.

2.7 Physical and Mental Training

2.7.1 Shooting Error

Generalizing shooting error could be difficult, but several researchers have found that elite basketball players shot more accurately when being filmed, and the opposite could be said about less experienced players (Hudson, Lee, & Disch, 1986; Spina et al., 1996). According to Spina and colleagues (1996), the elite shooter shot 100% from about the free throw line, whereas the intermediate shooter missed all of his shots under filming conditions; albeit, the sample size of two athletes was a major limitation. Overall, both shooters demonstrated the necessary stability and mobility to score a basket, but Spina and colleagues (1996) believed that the intermediate shooter did so at the cost of accuracy and height, both integral components of accurate shooting.

Another aspect of shooting error was related to where a player aimed when attempting to improve accuracy. Youth basketball players emulated the elite players of the National Basketball Association (Kuyper, 2015). As a result, the youth practiced shooting the way they saw the professionals shoot. Very few elite shooters used the backboard despite research showing that the backboard increased one's accuracy in most situations, the exception being when a shot was taken from farther away (Huston & Grau, 2003). Subsequently, many youth players developed a habit of looking for the straight shot at the hoop, when in reality, the backboard made for a more accurate shot, allowing youth players to focus on proper form (S. Komlenovic, personal communication, September 3, 2017). While this was important to understand, the issue was determining when a straight shot compared to a backboard shot was more effective (Huston & Grau, 2003).

A coach's ability to understand that elite players were different than youth players, should enhance the ability to develop proper shooting technique at a young age, promoting accuracy. McCormick (2009) stated that any poor upper body shot mechanics could be attributed to a lack of stability in the base. Insufficient lower body power production could produce a poorly aligned elbow or a flat shot with poor hip flexion (McCormick, 2009). One must understand the basic body movements before moving to more basketball-specific movements. Knowing and utilizing basics would lead to a more efficient and accurate shot, particularly when compared to observing the elite shooters.

2.7.2 Self-Talk

Self-talk, an athlete's internal dialogue, may influence his actions and emotional states (Zinsser, Bunker, & Williams, 1998). Self-talk tends to be linked to performance in a positive or negative way, rarely neutral (Sellars, 1997). Positive self-talk could be used to influence specific movements by way of self-reward, effort, attention, and anxiety (Theodorakis et al., 1998; Hardy, Jones, & Gould, 1996). The theory postulates that self-talk as a cognitive strategy potentially helps with performance and specific motor skills. However, in the literature, there were mixed results as to how well the self-talk approach was used effectively. According to Hardy and colleagues (1996), this was not surprising due to the difficulties of carrying out empirical work to measure self-talk and its influence on performance within sport. Zinsser and colleagues (1998) suggested that task-specific thoughts before a physical activity had a positive effect on the relevant skills; however, the process could become a distraction to completing the activity if it was too frequent and disrupted the flow of movement. From Moore and Stevenson's (1991) work, it was shown that this absence of an automatic response negatively affected one's trust in completing the task. As a result, self-talk should be focused on an outcome that was achievable (Theodorakis et al., 2001). When shooting a basket, it seemed important to have a relaxed mindset, enabling the person to focus in order to control the execution of the task, instead of being rushed and unprepared.

For skill acquisition, there were two types of self-talk, instructional and motivational, that would be useful for training an athlete (Zourbanos, 2013). Instructional self-talk would be more useful for the correction or development of specific skills, while motivational self-talk would be a better choice for enhancing self-confidence. The matching hypothesis has been suggested, arguing that instructional self-talk, such as "aim for the back rim, get a swish", would be more effective for precision and timing actions, like a jump shot, compared to motivational self-talk, such as “power through, I need to get up to dunk”, would be more effective for strength and endurance actions (Theodorakis et al., 2000; Hatzigeorgiadis et al., 2011). Task familiarity was also thought to be a possible parameter that may influence the effectiveness of self-talk, while taught self-talk had greater effectiveness for earlier stages of learning a task (Zourbanos, 2013). As a result, athletes and coaches must be mindful of the type of self-talk they utilize—positive or negative, and instructional or motivational—in order to promote maximal acquisition and mastery of a skill.

2.7.3 Mental Rehearsal

Mental rehearsal is the practice of physical skills without the actual movement of any muscle groups (Richardson, 1967). Throughout the literature it had been shown that observing and evaluating mental rehearsal skills were difficult to control due to the inability to see whether the player was mentally practicing a skill correctly or incorrectly (Kendall, 1988). Rushall (1979) described six situations which must occur for mental rehearsal to be effective: the athlete must imagine himself on the field of play; must play the sport in its entirety; the performance should be positive; this process must be done prior to the game; the level of performance should be realistic; the feel of the performance should be the focus. For example, a basketball player could mentally rehearse the next game by imagining the gym the game will be played in; imagining the whole 40 minutes; picturing that he was successful in the game; assuming he scored within his career averages; mentally focusing on how the ball felt in his hands; and the sound of the net as the ball passed through it. Furthermore, the athlete must understand and believe in the strategy for it to be as effective as possible (Botterill, 1987). In addition, Bandura (1978), suggested that athletes who have already learned or been exposed to a particular motor skill, like jump shooting, had a pre-designed and accurate representation of the sequences involved in the skill which enhanced the quality and effectiveness of the mental rehearsal. Subsequently, mental rehearsal would be less effective in facilitating the execution of unfamiliar motor skills, but would be more useful for a skilled shooter attempting to become more accurate (Mackay, 1981; Harris & Robinson, 1986). As a result, when adjusting a shooter's mechanics, it would be beneficial to teach mental rehearsal techniques only if the player had experience with shooting a basketball.

Mental rehearsal can provide a safe, stress-free environment to help athletes learn concepts or techniques (Manz & Neck, 1999). According to Arora and colleagues (2011), mental rehearsal also enhanced the ability of young surgeons to perform laparoscopic procedures. The mental rehearsal trained novice surgeons beyond just dexterity improvements but also improved the procedural outcomes (Arora et al., 2011). This was demonstrated, by the level of success in the five virtual laparoscopic cholecystectomies they had to complete, indicating that mental rehearsal was a positive part of the training (Arora et al., 2011). The tasks were mentally rehearsed ahead so the time needed to physically perform the task may be reduced (Arora et al., 2011). The learning curve required to understand the tasks through the stimulation of different parts of the brain would be flattened (Arora et al., 2011). Mental rehearsal as a whole would not be a replacement for a basketball practice but could be an effective facilitator for changing shooting mechanics to help increase a shooter's accuracy.

2.8 Video Analysis of Professional Athletes

2.8.1 The "Dip" and Newton's Law of Inertia

Personal review of all half-court video clips in the NBA during the 2016-2017 season using Synergy (Synergy Sports Technology, Phoenix, Arizona), a sport video software, demonstrated that the majority of players utilized a "dipping" motion in their jump shots, particularly from long range, during the catch and shoot situation. This project led to further video analysis of select current and former NBA shooting stars—Ray Allen, Reggie Miller, Steve Nash, Kyle Korver, and Stephen Curry. They exhibited many differences and similarities in their shooting form, such as differing release points and which fingers they pushed the ball with when shooting, while similar in having a "dipping" motion. Each player's height ranged from 6'3" to 6'7", which thereby affected their release height and necessary release angle, supported by Okazaki, Rodacki, & Satern (2015). Furthermore, the fundamentals of the shot, ranging from the concept of shoulder flexion to stability in the feet, would have been taught to the players, similarly with high school players. The concept of the "dip", and the effective use of it, in the shooting form were seen as the main contributor to the shooters' success as it was one of the consistent similarities among all the successful shooters.

In basketball, the shooting pocket was defined as the position that the basketball was in when a player began his jump shot. Biomechanically, the ball was in the shot pocket when all parts of the shooting arm including the hand, as well as the index and pointer fingers were in a vertical plane in front of the shoulder (Hoover, 2014). Subsequently, the "dip" would now be defined as the ball dropping below the shot pocket to initiate a player's jump shot (see figure 4.3, p 49). Newton's Law of Inertia states that an object at rest stays at rest and an object in motion stays in motion with the same speed and in the same direction unless acted upon by a net external force (Newton, 1687/1729). In a basketball context, this would mean that a basketball in motion and in line with the basket tends to stay in motion and in line until acted upon by an outside force, like someone blocking the shot. As a result, the longer and stronger the ball was in motion and in line, the more accurate a player's shooting became, explained scientifically by momentum and inertia. The six elite shooters that were observed demonstrated the ability to understand and utilize this law of motion. If a player hesitated, then he would have to restart the motion from where he stopped or slowed it down, making accuracy more difficult. The set point, the point where the shooting hand sets the ball before shooting, illustrated the importance of the "dip". A player would be determined to not have "dipped" the ball if it remained in the set point position, above the shooting pocket. Consequently, upon the personal analysis of the film, all six shooters' accuracy increased when they "dipped" the ball, rather than not "dipped", or launched from the set point.

These players had exceptional high-performance careers as elite shooters; as a result, it became interesting to investigate the idea of "dipping", something many of the professionals do, as being important to the play of younger players, ranging from high school to university, and to note if and how much their accuracy increased through use of the concept. Within the literature, there was no study in existence on the "dip", or if this movement increased shot accuracy. The only information about the "dip" was provided through anecdotal stories, new-age basketball coaching, and personal review of basketball film. Completing the proposed study on the "dip" would result in the first research knowingly available in scientific literature, as well as providing a strong foundation for coaches and researchers alike to utilize the information in a practical and scientific scenario.

Chapter 3

HYPOTHESES

Research Question #1: For basketball players, is "dipping" the ball more effective than "not dipping" in increasing the accuracy of the jump shot?

Research Sub-Question #1: Is the effective use of the "dip" distance-dependent?

H_0: The "dip" does not increase the accuracy of a player's jump shot.

H_A: The "dip" will increase the accuracy of a player's jump shot.

Research Question #2: If basketball players naturally "dip" or do not "dip", does it impact the accuracy of the shot when the "dip" is implemented?

H_0: Whether a shooter naturally "dips" or not, does not impact the accuracy of his shot when he does "dip".

H_A: Whether a shooter naturally "dips" or not, does impact the accuracy of his shot when he does "dip".

The main independent variables were:

1. Whether the shot was required to be "dipped" or not
2. If the player was already a "dipper"
3. The distance from which the shots were being taken

The dependent variable was:

1. The 6-point score quality of the shot

The secondary dependent variables were:

1. Shot Speed
2. Shot Arc

The skill of the player as an independent variable was accounted for by looking at the two groups, high school and university, separately. Furthermore, since the secondary variables were added after the hypotheses were developed, the detailed results of the secondary dependent variables have been included in Appendix E.

Chapter 4

RESEARCH DESIGN

4.1 Method

4.1.1 Participants

The various levels of basketball have many skill levels; thus, male players from several levels were observed, ranging from high school, provincial team players and regional team players, as well as university players. Permission was received from the University of Manitoba Bison men’s team through the head coach and the assistant Athletic Director. High school boys’ teams comprised of 2017 provincial team players and 2016 Manitoba Games players were also contacted. Further permission from the Technical Director of Basketball Manitoba was received in order to allow the various players from each of the teams to participate in the present study. Permission to conduct the present study was also granted by the Education/Nursing Research Ethics Board (ENREB) at the University of Manitoba. Individual players gave written informed consent prior to participation. In cases where players were under 18 years of age, a parent or guardian provided written informed consent and the player provided written assent.

According to the rosters, there were 18 participants from the University of Manitoba men’s team, and 18 participants from the high school level, selected from within the 2017 under 17 Team Manitoba provincial team and 2016 under 16 Manitoba Games regional teams during their respective off seasons. The participants’ ages ranged from 18-24 at the university level, and 15-17 at the high school level. There were 18 participants in each group. An athlete was excluded from this study only if they did not meet the following two requirements:

1. Had not played basketball for four years in an elite setting such as the provincial team, a regional team or a club team.
2. Had a pre-existing injury particularly to the shoulder, wrist, hand, hip, knee, or ankle less than six months prior to the study date. This was self-reported.

4.1.2 Sample Size

Throughout the 2016/17 season, the University of Manitoba Bison maintained a 45.00% field goal percentage, the ratio of shots made by a player and shots attempted by the player, making 796 successful shots while attempting 1769 shots. During the 2017 Canada Summer Games, the Manitoba provincial team scored 154 shots and attempted 358 shots, resulting in a field percentage of 43.01%. During the 2016 Manitoba Games, the Winnipeg Gold regional team scored 126 shots and attempted 314 shots, resulting in a field percentage of 40.13%. In order to get an average high school percentage, the two sets of shots made and attempted were combined. The result was a high school field goal percentage of 41.67%. Therefore, to err on the side of caution, the sample size was estimated based on a 42% success rate currently, slightly lower than the calculated 44.08% of all teams combined due to skewing from the university numbers, and a proposed 19% increase while using the “dip”, based on the results within the pilot study, bringing the teams’ field percentages to 50%. The program G*Power was used to calculate the necessary sample size for the current study. Assuming an α of 0.05, since the main hypothesis was one-tailed, and 80% power to detect a significant difference between “dipped” and “non-dipped” shots was used, the sample size required was 24 athletes in total. Furthermore, when reviewing the literature on jump shots and increased distance, the studies used sample sizes of 15, 15, 10, and 8 (Miller & Bartlett, 1993; Miller & Bartlett, 1996; Okazaki & Rodacki, 2012;

Keetch et al., 2005). As a result, by using 34 athletes instead of 24 in the present study, there was a 34.48% margin in case some of the athletes did not show up or did not follow instructions. Within the study, 100% of athletes showed up and all followed the instructions correctly. Furthermore, an additional athlete in each group participated, resulting in a total sample size of 36 athletes, 18 per group.

The study focused on an entire team's roster, rather than a selection of 18 players, because in a roster there will be star players and role players, players who took on a specific skill and role within the team such as defense or rebounding. If 18 randomly selected players were used, there was a chance that the roster would consist of only star players or role players. This type of selection would skew interpretation of the results in either direction due to the fact that the star player may have more practice shooting the basketball when compared to a role player.

When looking at the participants for the present study a sample of convenience was used. The principal investigator is a basketball coach with eight years of coaching experience, including six at the university level. Furthermore, the principal investigator has been highly involved with basketball in Manitoba, including coaching with the provincial team. As a result, the two largest universities in the province were contacted. The assistant athletic director of one of the universities did not reply to the request, but 18 out of 19 athletes at the other university participated, resulting in a 94.7% recruitment rate in the university group available. Within the high school group, each team had twelve athletes, with two athletes being on both teams. As a result, 18 out of 22 athletes participated, resulting in an 81.8% recruitment rate.

4.1.3 Dependent Measures

In basketball, success of an offensive player is usually derived from the player's field goal percentage, or the accuracy of the player's shooting. As a result, measuring the differences between the field goal percentages of "dipped" and "non-dipped" shots of each player within the study at each spot was important. While this is a simple way of looking at player success, it will not always give a clear indication of the quality of the shot. A few point systems have been used in the literature such as the 4-point system used by Keetch and colleagues (2005). However, the 6-point system used by Hardy and Parfitt, (1991) divided non-"swished" shots into two separate categories: rim and in, and backboard and in, making it more specific. More recent work by Lam and colleagues (2009a; 2009b) utilized the Hardy and Parfitt scale. As a result, the six-point scale of shot quality was used. This scale helped to justify whether the "dipped" and "non-dipped" shots were of high quality and gave value beyond whether the shot went in or not. Professional players sought to perfect their craft, and so, the "swish" or "clean basket" was an indication that the shot was of high quality. This data helped give a better picture as to the influence of the "dip", if such an influence existed.

4.1.4 94Fifty Smart Sensor Basketball

A 94Fifty Smart Sensor Basketball (InfoMotion Sports Technologies, Inc., Attleboro, Massachusetts) was used for the study instead of the basketballs located in the gym in order to collect more data about the players' shots, including release time and shot arc. The 94Fifty basketball was identical to a regulation basketball in terms of size and weight (see Figure 4.1) and therefore, acted and felt like a regular basketball, reducing any impact from its use. However, this ball measured release time, enabling one to see if there was a difference between “dipped” and “non-dipped” shots in release times and shot arc. While these components were not directly needed for the study, they enhanced the results by providing supporting details regarding the shots taken. InfoMotion Sports Technologies created this basketball to help improve a player’s training session by providing feedback on the aforementioned components of the jump shot, as well as taking into account the height of the player. InfoMotion inserted a microelectromechanical systems (MEMS) tri-axis accelerometer and gyroscope to track the motion of the ball, capturing 6000 pieces of movement data per second within its digital signal processing hardware (DiPaola, 2013; Bal, 2013). The addition of the gyroscope increased the accuracy of the ball through faster response rates, tracking small,

Figure 4.1. 94Fifty Smart Sensor Basketball.

quick movements more quickly, making it possible to detect any linear acceleration separate from gravity; whereas an accelerometer was considered a noisy sensor, meaning they have a slow response rate due to noisy filtering and the measurements were affected by motion ("Basics of Motion Application Development", 2017). The ball used IoEdge software to provide precise motion data, resulting in a 100-millisecond speed from jump shot to visual display, connected by Bluetooth technology to the researcher's phone. Furthermore, the nine sensors and gyroscope weighed a combined 20 grams (Nelson, 2014). Developers changed other pieces of the ball to compensate for the weight gain, resulting in a ball that did not feel any different from a regular basketball (Nelson, 2014). Ultimately, the ball used advanced pattern recognition algorithms to automate motion capture, monitoring the participant's release speed and angle without causing players to make adjustments to their shots. The supplementary data collected via this ball are presented in Appendix E.

4.1.5 Protocol

The protocol for this study was similar to that of the pilot study. Each team's home gym had the appropriate International Basketball Federation (FIBA) court markings; as a result, these markings were used to help maintain a level of familiarity for the player, rather than shooting at randomly marked spots. Each of these spots, marked by 15 centimetres pieces of tape, were all common places for a player to shoot from: the top lane line from the basket (3.125m), an extra lane line length from the free throw line (4.925m), the top of the free throw circle (6.025m), and the three-point line (6.75m). In the case of a high school shooter, he was asked to shoot from spot 4 (see figure 4.2) at 6.75m, even though the high school three-point line was slightly shorter at 6.25m. This change was made so the groups were more easily compared and was not a problem as elite high school athletes were expected to train at the university distance in order to move on to the next level. The teams that were tested shot in their home gym, to reduce any effects from unfamiliarity with the gym. Each team was divided into groups of two players per session. This division was to eliminate bias from other players watching the experiment, and help with the teaching component, by not seeing how another player performed, when demonstrating the “dipping” motion. All athletes, or parents for shooters under 18, were required to sign a consent to participate prior to the shooting session. At this time, the researcher took basic demographic information from each player, including height, measured using a measuring tape against the wall, handedness, years playing the sport, and position (see Table 5.1).

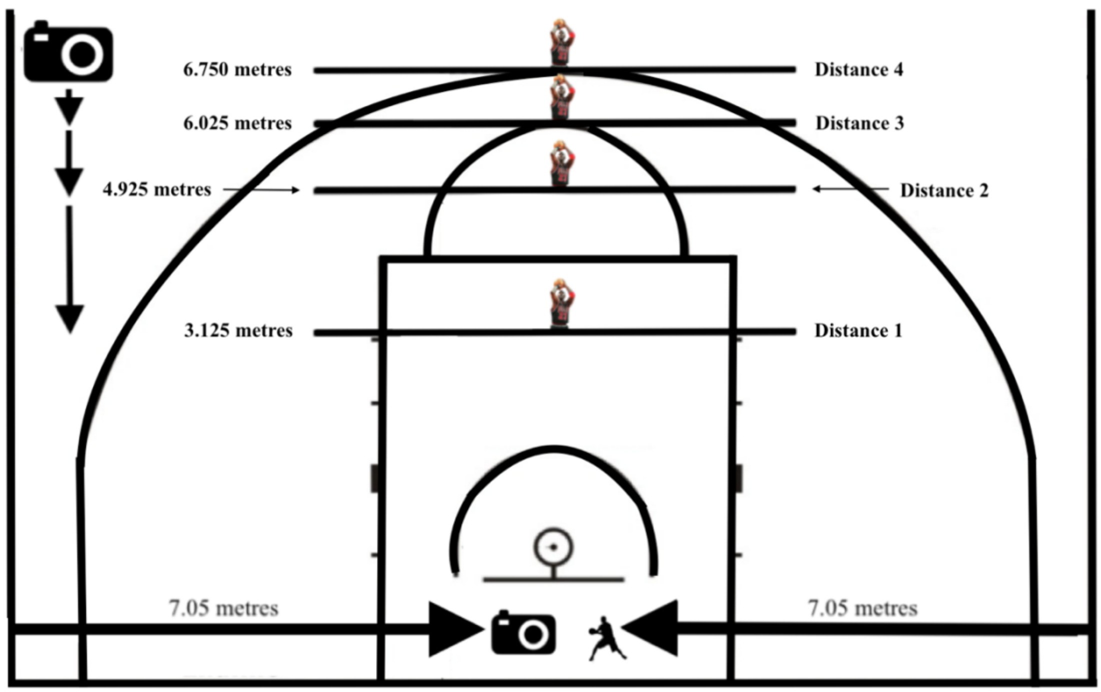

Figure 4.2. Design of the Study (Adapted from “FIBA Rules”, FIBA Central Board, 2014

As each group of two players entered the gym, they were instructed to take ten game-like warm-up shots separately from each marked spot, being videotaped the entire time. The order was chosen by the player, but ten shots had to be taken in a row, and each partner group decided who went first. One teammate made the passes to the other, but no explanation was provided

beyond this task. These shots helped create a baseline for the player to determine if the experimental shots deviated from the player's normal accuracy levels and if the players normally "dipped" or did not. Once the shots were
taken, the player was labelled as a "dipper" or "non-dipper" at each spot, by the principal investigator, depending on their shooting form. This was confirmed by the research assistant, who would play back the film during the explanation phase, as it was not always easy to identify by just watching, especially if the shooter had an extremely quick release. At this point, the players received a player identification. This identification consisted of two parts: a letter sequence and a number sequence. The letter sequence was "D" or "ND", representing whether the shooter was naturally a "dipper" or "non-dipper". The number sequence determined what shooter they were in the study. For example, the sixth "dipper" of the study was "D06". The player was made aware of these designations as well as the procedure for the rest of the trial by the principal investigator.

Cameras were set up so that a side view and a front view were taken, with the front view camera and passer in alignment on either side of the backboard so that there were not more objects on one side of the basket, thus reducing lateral bias (see Figure 4.2). Specifically, the standard basketball backboard was 6 feet wide, or 1.82m. As a result, the front view camera was placed so that the camera was located 0.46m from the edge of the backboard, on either side. Which side it would be located on would be dependent on the handedness of the shooter; for example, if the shooter was left handed, the camera was on the right side of the backboard so that the passer could be on the left side. The passer was located at 0.46m from the edge of the backboard on the opposite side of the camera. In order to make these calculations efficiently, the researcher measured from each sideline and placed a 15cm piece of tape down where the centre of the camera and passer was located. The distance measured from each sideline was 7.05m. Conversely, the side view camera was placed directly on the sideline perpendicular to the shooter and moved to each of the four shooting spots. These movements were done during the 30 second timed breaks for the shooter.

The principal investigator first described, then demonstrated the “dip” versus a “non-dip”, to give the player auditory and visual instructions. The emphasis in the instructions was placed on what a “dip” looked like and the key components. The following three points were discussed with the athletes as the key emphasis for the “dip”. The researcher demonstrated the “dip” when talking about points 1 and 2 while demonstrating a “non-dip” when referring to point 3. The athletes were then able to ask questions to clarify their thoughts on each, particularly the shot style they did not naturally use. In Figure 4.3, a University of Manitoba Bison player demonstrated several key points of the “dip”:

1. In the first image, the player caught the ball and placed it in the shooting pocket.
2. In the second image, the ball was lowered below this shooting pocket, resulting in his shooting fingers and arm changing direction. This change of direction required at least a 90° rotation of the shooting fingers out of the finger plane if the elbow angle did not increase or at least a 90° increase between the elbow and wrist joints. For example, if the wrist angle was only 75°, but the elbow angle increased by 15°, from 90° to 105°, this was deemed acceptable as a “dip”.
3. When referring to the second image, if the Bison player kept the ball in the shooting pocket, and simply lowered his legs, without changing the direction of the shooting fingers and arm, this would not be considered a “dipped” shot.

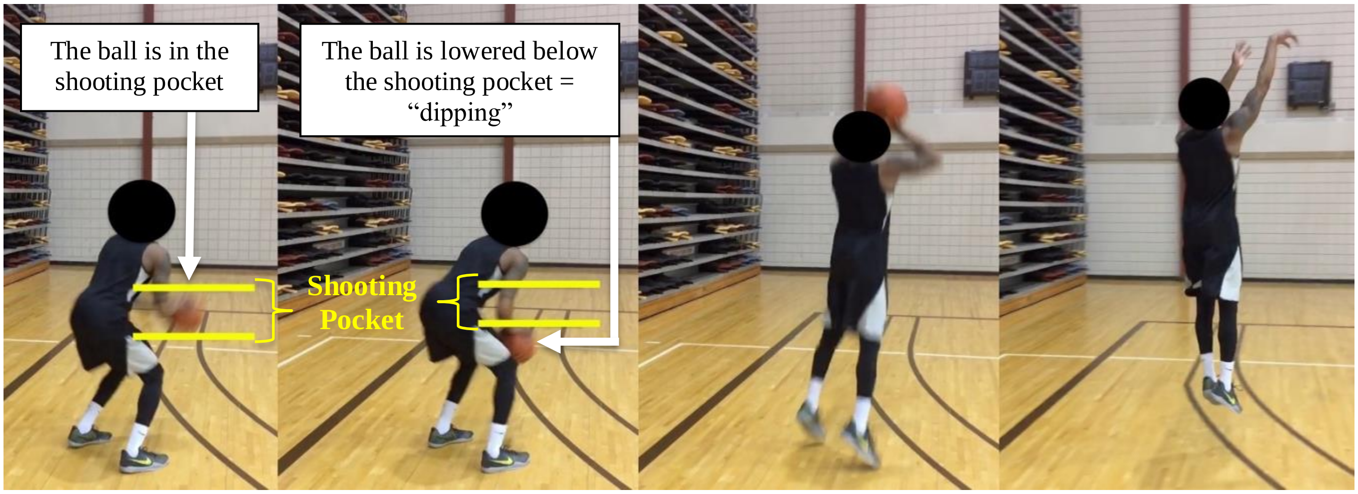

Figure 4.3. University of Manitoba Bison Player Shooting Form Illustrating the "Dip".

The video helped confirm whether the athletes had "dipped" or not, depending on the shot type. Prior to the study, the researcher generated a list of 18 sets of randomized numbers, one for each player in each skill level group. A randomization with replacement procedure was used where after all groups from the day were done the numbers were replaced with new ones corresponding to one of the four spots shot from on the court, using the "Research Randomizer" program online (Urbaniak & Plous, 2017). The 18 choices were then printed from the "Research Randomizer" website and placed in an envelope for picking. At random, the athlete picked one and shot from the spots in that order, one being the spot closest to the basket and four being the farthest (see Figure 4.2). The researcher used the randomizer to generate 18 more lists of randomized sequences of "dips" and "non-dips" picked again by the athlete. Since these lists were longer, they were placed upside down for the athlete to pick and hand to the researcher. Of importance is that the maximum number of athletes filmed in one day was four, and after each day, the lists were rerandomized, resulting in 18 new lists for distance order and shot type order.

The researcher proceeded to tell the shooter whether to “dip” or not before each shot, using the selected randomized list (see Appendix A), shooting ten “dipped” and ten “non-dipped” shots at each spot. The passer was instructed to continue passing as if in a game, and the shooter took the shots as if in a game situation with defenders. All twenty shots occurred at the same spot before proceeding to the next one. The passer rebounded the ball after every shot. In the case that the shot was missed and the rebounder could not retrieve it immediately, the research assistant was ready to retrieve it, pass it back to the passer, and continue with the passes. In cases like this, the shooter was required to stay at the shooting spot and be ready to shoot whenever the ball was given back to the passer. After each set of twenty shots, a thirty second timed break was given to reduce any fatigue factors, particularly at the end of the progression, or group of shots. Ultimately, the player shot forty warm-up shots and eighty recorded shots, similar to Viggiano and colleagues’ (2014) experiment, resulting in each athlete’s shoot time of approximately 15-20 minutes, and the 5-minute explanation period for what the “dip” looked like. Overall, testing took about 35-45 minutes per pair of athletes. The researcher recorded three things:

1. The point quality of the shot based on the 6-point scale (see table 4.1), using the researcher’s observation as judgement for the value, every shot later verified using the video. For example, if the ball hit the rim first then backboard and in, the value was 5 for “rim and in”. Conversely, if the ball hit the backboard first then rim and in, the value was 4 for “backboard and in”.
2. The release time of the shot, as observed by the 94fifty basketball application on the researcher’s smartphone connected via Bluetooth to the ball.

3. The shot arc, as observed by the 94fifty basketball application on the researcher's smartphone connected via Bluetooth to the ball.

Whether the shot was "dipped" or "non-dipped" was already typed onto the 18 sheets of paper prior to selection by the researcher for ease of observation. To determine whether the basket was successful, a score of 1-3 denoted a "miss" shot and 4-6 denoted a "made" shot (see Table 4.1). Lastly, at the end of the protocol, each pair of players was taken to a private area and asked a question by the principal investigator. The question depended on the prior status of the shooter as a "dipper" or "non-dipper". If the shooter was labelled as a "dipper", the question was: "Why do you think you use the 'dip'?" If the shooter was labelled as a "non-dipper", the question was: "Why do you think you do not use the 'dip'?" The answers from the players provided an athlete's view of the "dip".

Table 4.1
6-point Shooting Scale based on Hardy and Parfitt (1991)

Scale Value	Description	Made/Missed
6	"Clean" basket ("swish")	MADE
5	Rim and in	MADE
4	Backboard and in ("bank shot")	MADE
3	Rim and out	MISSED
2	Backboard and out	MISSED
1	Complete miss ("air ball")	MISSED

Note: Hardy-Parfitt scale starts at "0", this scale starts at "1"

A professional Serbian basketball shooting coach, affiliated with the University of Manitoba Bison basketball team, requested an interview with the principal investigator to discuss the "dip" after hearing about the study during the university player meeting. Following an amendment to the approved procedures, the principal investigator asked six questions related to the "dip" and its use during a meeting with the coach. The additional coach insight can be found in Appendix B.

4.1.6 Data Analysis

The accuracy score of the shooters in the study were determined by adding the score values at each spot using each shooting motion, with a maximum of 60 points for 10 swishes and a minimum of 0 for 10 air balls. These scores were averaged to get the final score used for statistical analysis. During the warm-up, players took ten jump shots at each spot to create a baseline to determine the athlete's ability and identify their shooting style prior to the testing. For example, if a player already "dips", then the warm-up shots would be "dipped". The "dipped" experimental shots at each spot were then compared to the baseline shots using a paired-samples t-test. The paired-samples t-test compared two means that were from the same group, allowing for the researcher to see if any difference existed. Ideally, this test would show that there was no significant statistical difference from zero between the warm-up and experimental shots, demonstrating that the group's results were more reliable. Since this study dealt with three independent variables: whether the shot was "dipped" or not; if the player was already a "dipper"; the distance from which the shots were being taken; and one dependent variable: the 6-point shot quality scale; a mixed model analysis of variance (ANOVA) with two repeated measures was used to look at the results of the study. In a mixed model ANOVA with two repeated measures, the three independent variables were: whether the player was a "dipper" or not, whether the shot was "dipped" or not, and the distance the shots were taken, with the latter two being repeated measures. The variables were used to determine if there was an interaction effect between them on an interval measurement scale for a continuous dependent variable, being the 6-point score quality of the shot. In order for it to be a repeated measures ANOVA, the within-subjects factors, in this case, whether the shot was required to be "dipped" or not and the distances the shots were being taken, were measurements made under different conditions. These conditions were called levels of the independent variable; for example, “dipped” shots and “non-dipped” shots were the two levels of the independent variable of whether the shot was required to be “dipped” or not (see Figure 4.4).

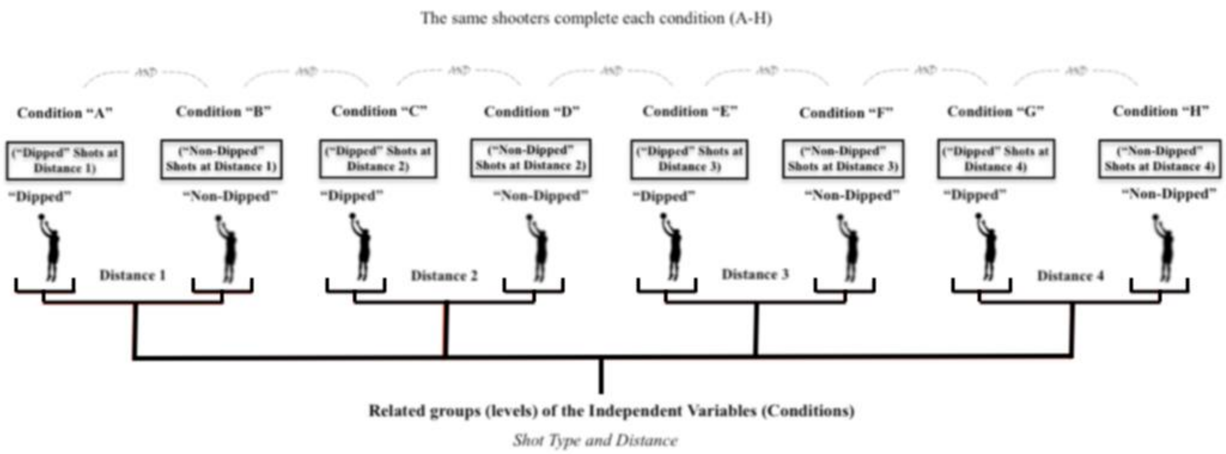

Figure 4.4. Different Conditions Repeated Measures ANOVA Design.

The repeated measures ANOVA tests whether there were any differences between estimated population means; for example, the differences in accuracy between “dippers” and “non-dippers”.

Using the Statistical Package for the Social Sciences ([SPSS], International Business Machines Corporation, Armonk, New York), the data set was analyzed, generating the appropriate F-statistics. To test for the assumptions of the mixed model ANOVA, several tests were used:

1. Shapiro-Wilks test of normality with no corrections needed
    a. Graphically, with the quantile-quantile (Q-Q plot)
2. Mauchly’s test of sphericity with no corrections needed

If the results were statistically significant, then a post-hoc test was conducted to see where the interactions occurred. A Fisher's Least Significant Difference (LSD) test with the Bonferroni adjustment was used to find out the smallest significance between two means, resulting in anything larger than this difference being a significant result. If significant interactions were identified, then a paired-samples t-test would be run between each of the combinations of the interaction to look for significance. Lastly, for the secondary dependent variables of release time and shot arc, additional ANOVAs were performed for each.

Chapter 5

RESULTS

5.1 Demographics

5.1.1 Athletes

For this study, elite high school and university basketball players were used to ascertain if using the “dip” in a jump shot increased accuracy. The overall sample population was 36 athletes. Within the university group (see table 5.1), the mean age of the athlete was 20.3 years (Standard Deviation [*SD*] = 1.8 years), having a mean of 11.1 years of basketball experience (*SD* = 2.2 years). By comparison, the high school group (see table 5.1) had a mean age of 16.7 years (*SD* = 0.9 years), having a mean of 6.3 years of basketball experience (*SD* = 2.0 years). The mean height of the university players was 191.6 cm (*SD* = 7.4 cm) while the mean height of the high school players was 186.6 cm (*SD* = 10.02 cm). Within the university group, there were eight guards, eight forwards and 2 centres (Number of subjects [*n*] = 18), and within the high school group, there were six guards, nine forwards, and 3 centres (*n* = 18). Lastly, the university group had one left-handed shooter and seventeen right-handed shooters while the high school group also had one left-handed shooter and seventeen right-handed shooters.

Table 5.1
Demographics of the High School and University Basketball Players

		Dippers			Non-Dippers		
	Factor		Average	Standard Deviation		Average	Standard Deviation
High School Players	n	13			5		
	Age	-	16.6	1.0		17.0	0.7
	Years of Experience	-	6.4	2.3		6.0	1.0
	Height	-	187.2	11.1 cm		185.0 cm	7.3 cm
		-	6'1.7"	4.4"		6'0.9"	2.9"
University Players	n	10			8		
	Age	-	20.1	1.0		20.5	2.3
	Years of Experience	-	10.8	2.6		11.5	1.8
	Height	-	189.3 cm	8.9 cm		194.4 cm	3.9 cm
		-	6'2.1"	3.5"		6'4.6"	1.6"

Both groups had the same ratio of left to right handedness, and similar positional groupings, with the high school having fewer guards in replacement of more forwards and centres. The main difference was age, and subsequently, the years of basketball experience, as the university group had to move through the high school levels first. With the university group being approximately three years older on average and having five more years of basketball experience, the groups were analyzed separately based on skill level, and the level of competition. The mean scores of each group on the shooting task are reported in Table 5.2.

Table 5.2
Summary of Means in Shooting Data

	Means		
	Distiance and Shot Type	Mean	Standard Deviation
High School Dippers			
	Distance 1 and Dipped	4.9	0.46
	Distance 2 and Dipped	4.4	0.49
	Distance 3 and Dipped	4.3	0.41
	Distance 4 and Dipped	4.4	0.59
	Distance 1 and Non-Dipped	4.6	0.62
	Distance 2 and Non-Dipped	4.1	0.44
	Distance 3 and Non-Dipped	3.8	0.57
	Distance 4 and Non-Dipped	3.5	0.51
High School Non-Dippers			
	Distance 1 and Dipped	4.6	0.68
	Distance 2 and Dipped	4.3	0.69
	Distance 3 and Dipped	4.0	0.30
	Distance 4 and Dipped	4.0	0.60
	Distance 1 and Non-Dipped	4.4	0.74
	Distance 2 and Non-Dipped	4.1	1.01
	Distance 3 and Non-Dipped	3.7	0.50
	Distance 4 and Non-Dipped	3.4	0.50
University Dippers			
	Distance 1 and Dipped	5.0	0.48
	Distance 2 and Dipped	5.0	0.44
	Distance 3 and Dipped	4.5	0.26
	Distance 4 and Dipped	4.4	0.39
	Distance 1 and Non-Dipped	4.3	0.41
	Distance 2 and Non-Dipped	4.4	0.42
	Distance 3 and Non-Dipped	4.0	0.57
	Distance 4 and Non-Dipped	4.0	0.47
University Non-Dippers			
	Distance 1 and Dipped	5.1	0.42
	Distance 2 and Dipped	4.7	0.49
	Distance 3 and Dipped	4.4	0.38
	Distance 4 and Dipped	4.3	0.57
	Distance 1 and Non-Dipped	4.8	0.55
	Distance 2 and Non-Dipped	4.5	0.61
	Distance 3 and Non-Dipped	4.3	0.39
	Distance 4 and Non-Dipped	4.1	0.59

5.2 Quantitative Results

5.2.1 Tests of Sphericity: Mauchly's Test of Sphericity

The Mauchly's Test was run on all of the groups and shooter types to see if sphericity was violated (see table 5.3). Due to having only two levels for the repeated measure of shot type, there was only one set of difference scores and nothing to compare those difference scores against to indicate a violation of sphericity. Therefore, the repeated measures of distance was reported, and the assumption of sphericity was held for shot type, based on those results. For the high school "dippers", Mauchly's Test of Sphericity indicated that the assumption of sphericity had not been violated, $\chi^2(5) = 3.028$, $p = 0.697$. For the high school "non-dippers", Mauchly's Test of Sphericity indicated that the assumption of sphericity had not been violated, $\chi^2(5) = 3.814$, $p = 0.598$. For the university "dippers", Mauchly's Test of Sphericity indicated that the assumption of sphericity had not been violated, $\chi^2(5) = 3.285$, $p = 0.658$. For the university "non-dippers", Mauchly's Test of Sphericity indicated that the assumption of sphericity had not been violated, $\chi^2(5) = 5.255$, $p = 0.392$. As a result, the significance values would be taken from the "sphericity assumed" row (see table 5.4).

Table 5.3
Mauchly's Test of Sphericity

	Within-Subjects Effect	Mauchly's W Statistic	Chi-Squared	df	Significance
High School Dippers					
	Shot Type	1.000	0.000	0	-
	Distance	0.754	3.028	5	0.697
	Shot Type * Distance	0.723	3.482	5	0.627
High School Non-Dippers					
	Shot Type	1.000	0.000	0	-
	Distance	0.246	3.814	5	0.598
	Shot Type * Distance	0.234	3.958	5	0.578
University Dippers					
	Shot Type	1.000	0.000	0	-
	Distance	0.654	3.285	5	0.658
	Shot Type * Distance	0.524	4.996	5	0.420
University Non-Dippers					
	Shot Type	1.000	0.000	0	-
	Distance	0.399	5.255	5	0.392
	Shot Type * Distance	0.467	4.362	5	0.504

Table 5.4

Levels of Significance, "Sphericity Assumed"

	Sphericity Assumed					
	Within-Subjects Effects	Type III Sum of Squares	df	Mean Square	F-Statistic	Significance
High School Dippers						
	Shot Type	6.155	1	6.155	31.711	0.000
	Distance	9.233	3	3.078	14.410	0.000
	Shot Type * Distance	1.644	3	0.548	4.769	0.007
High School Non-Dippers						
	Shot Type	1.225	1	1.225	8.167	0.046
	Distance	3.925	3	1.308	3.504	0.049
	Shot Type * Distance	0.325	3	0.108	1.140	0.372
University Dippers						
	Shot Type	6.441	1	6.441	74.309	0.000
	Distance	3.928	3	1.309	12.670	0.000
	Shot Type * Distance	0.159	3	0.053	0.443	0.724
University Non-Dippers						
	Shot Type	0.723	1	0.723	5.950	0.045
	Distance	4.526	3	1.509	5.958	0.004
	Shot Type * Distance	0.039	3	0.013	0.163	0.920

5.2.2 Test of Normality: Shapiro-Wilks Test

A Shapiro-Wilks test was used to test for normality on the main dependent variables of shot type and distance. These results indicated that the data was normally distributed (see table 5.5). Therefore, the data could be analyzed further for outliers.

Table 5.5
Shapiro-Wilks Test of Normality

		Shapiro-Wilks		
	Distance and Shot Type	Statistic	df	Significance
High School Dippers				
	Distance 1 and Dipped	0.939	13	0.449
	Distance 2 and Dipped	0.972	13	0.915
	Distance 3 and Dipped	0.974	13	0.940
	Distance 4 and Dipped	0.964	13	0.814
	Distance 1 and Non-Dipped	0.954	13	0.658
	Distance 2 and Non-Dipped	0.949	13	0.586
	Distance 3 and Non-Dipped	0.941	13	0.465
	Distance 4 and Non-Dipped	0.888	13	0.090
High School Non-Dippers				
	Distance 1 and Dipped	0.856	5	0.213
	Distance 2 and Dipped	0.880	5	0.312
	Distance 3 and Dipped	0.956	5	0.777
	Distance 4 and Dipped	0.979	5	0.930
	Distance 1 and Non-Dipped	0.836	5	0.153
	Distance 2 and Non-Dipped	0.967	5	0.859
	Distance 3 and Non-Dipped	0.820	5	0.117
	Distance 4 and Non-Dipped	0.827	5	0.131
University Dippers				
	Distance 1 and Dipped	0.960	10	0.788
	Distance 2 and Dipped	0.963	10	0.818
	Distance 3 and Dipped	0.927	10	0.419
	Distance 4 and Dipped	0.898	10	0.209
	Distance 1 and Non-Dipped	0.955	10	0.730
	Distance 2 and Non-Dipped	0.970	10	0.893
	Distance 3 and Non-Dipped	0.943	10	0.591
	Distance 4 and Non-Dipped	0.845	10	0.051
University Non-Dippers				
	Distance 1 and Dipped	0.918	8	0.413
	Distance 2 and Dipped	0.874	8	0.166
	Distance 3 and Dipped	0.959	8	0.804
	Distance 4 and Dipped	0.909	8	0.348
	Distance 1 and Non-Dipped	0.962	8	0.831
	Distance 2 and Non-Dipped	0.943	8	0.638
	Distance 3 and Non-Dipped	0.927	8	0.493
	Distance 4 and Non-Dipped	0.950	8	0.709

5.2.3 Outliers

Since the assumption of normality had not been violated, the next step would be to check if there were significant outliers. In order to test for any potential outliers in the data, the interquartile range (IQR), the range of data between the first quartile (25% of the data) and the third quartile (75% of the data), was used (see equation 7), where IQR was the range of data

$$\boxed{IQR = Q_3 - Q_1} \quad (7)$$

Interquartile Range

Q_3 was the third, or upper, quartile and Q_1 was the first, or lower, quartile. Tukey (1977) used the IQR multiplier method, multiplying the IQR by 1.5, to find the range of data that would be accepted as not being an outlier. With this method, outliers would be found if the values were below (see equation 8)

$$\boxed{Q_1 - (1.5 * IQR)} \quad (8)$$

Outliers Below Interquartile Range

or above (see equation 9)

$$\boxed{Q_3 + (1.5 * IQR)} \quad (9)$$

Outliers Above Interquartile Range

resulting in a range. SPSS was used to identify outliers in the data; however, Hoaglin, Iglewicz, and Tukey (1987) developed an “outlier-labelling rule”. Later on, Hoaglin and Iglewicz (1987) demonstrated that Tukey’s 1.5 multiplier was inaccurate approximately half of the time. As a result, the authors suggested a better multiplier would be 2.2 for sample sizes smaller than 50 participants (Hoaglin and Iglewicz, 1987). On a stem-and-plot graph (see figure 5.1), the outliers were labelled on the graph by circles using the 1.5 multiplier. The principal investigator then went through the data, locating these outliers. Once outliers were located, more analysis was required, using equations 11 and 12.

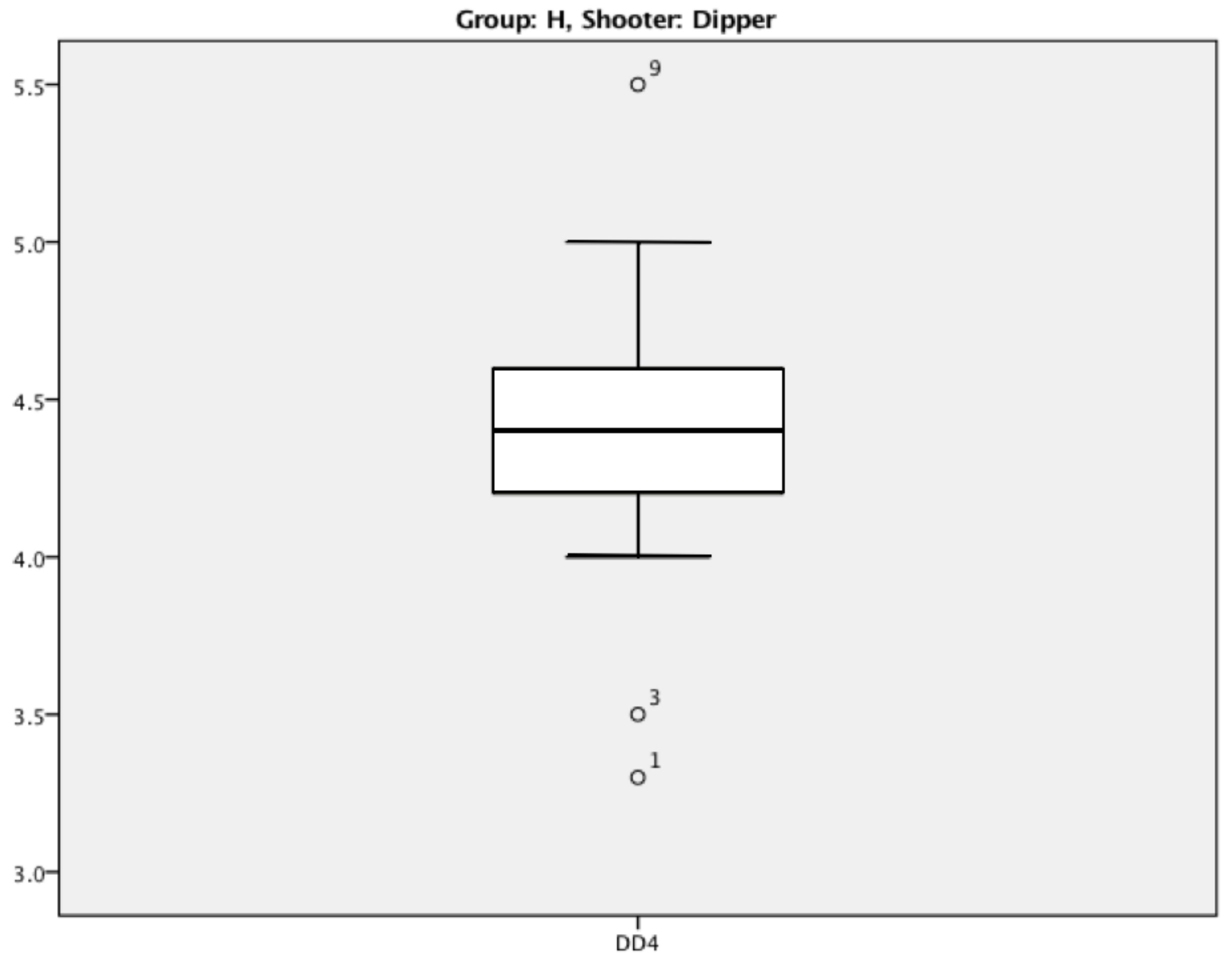

Figure 5.1. “Potential Outliers” in High School “Dippers”, “Dipped” Shots Distance 4

Mathematically, the calculation for the outlier-labelling rule would be for the lower boundary (see equation 10)

$$\boxed{Q_1 - (2.2 * IQR)} \tag{10}$$

Hoaglin and Iglewicz’s Adjustment for Lower Boundary

and the upper boundary (see equation 11)

$$\boxed{Q_3 + (2.2 * IQR)} \tag{11}$$

Hoaglin and Iglewicz’s Adjustment for Upper Boundary resulting in a larger boundary but also a more valid approach to detecting outliers. Using the 25th and 75th percentile data provided by SPSS (see table 5.6), the outliers were input into equations 11 and 12 to create new lower and upper boundaries.

Table 5.6

Interquartile Percentile Data and Extreme Values

		Percentiles		Extreme Values			
	Distance and Shot Type	25	75	Highest		Lowest	
High School Dippers							
	Distance 1 and Dipped	4.55	5.20	5.5	5.4	3.8	4.5
	Distance 2 and Dipped	4.15	4.90	5.2	5.0	3.4	3.9
	Distance 3 and Dipped	4.00	4.60	5.1	4.9	3.7	3.9
	Distance 4 and Dipped	4.10	4.75	5.5	5.0	3.3	3.5
	Distance 1 and Non-Dipped	4.10	5.10	5.5	5.4	3.6	3.7
	Distance 2 and Non-Dipped	3.80	4.55	4.8	4.6	3.3	3.7
	Distance 3 and Non-Dipped	3.35	4.30	4.7	4.7	3.0	3.2
	Distance 4 and Non-Dipped	3.10	3.90	4.5	4.3	2.9	3.1
High School Non-Dippers							
	Distance 1 and Dipped	4.00	5.10	5.2	5.0	3.5	4.5
	Distance 2 and Dipped	3.65	5.00	5.0	5.0	3.5	3.8
	Distance 3 and Dipped	3.75	4.30	4.5	4.1	3.7	3.8
	Distance 4 and Dipped	3.55	4.60	4.9	4.3	3.3	3.8
	Distance 1 and Non-Dipped	3.70	5.00	5.0	5.0	3.3	4.1
	Distance 2 and Non-Dipped	3.15	5.10	5.2	5.0	2.6	3.7
	Distance 3 and Non-Dipped	3.15	4.05	4.1	4.0	3.0	3.3
	Distance 4 and Non-Dipped	3.05	3.90	4.2	3.6	3.0	3.1
University Dippers							
	Distance 1 and Dipped	4.75	5.33	5.8	5.7	4.2	4.6
	Distance 2 and Dipped	4.60	5.40	5.6	5.4	4.2	4.6
	Distance 3 and Dipped	4.40	4.68	5.0	4.9	4.1	4.4
	Distance 4 and Dipped	4.08	4.75	5.1	4.9	4.0	4.0
	Distance 1 and Non-Dipped	3.90	4.55	5.1	4.7	3.7	3.9
	Distance 2 and Non-Dipped	4.15	4.73	5.0	4.8	3.6	4.0
	Distance 3 and Non-Dipped	3.65	4.60	4.7	4.6	2.9	3.5
	Distance 4 and Non-Dipped	3.58	4.33	4.4	4.4	3.1	3.2
University Non-Dippers							
	Distance 1 and Dipped	4.73	5.40	5.5	5.4	4.3	4.7
	Distance 2 and Dipped	4.33	5.23	5.5	5.3	4.2	4.3
	Distance 3 and Dipped	4.05	4.68	5.0	4.7	3.9	4.0
	Distance 4 and Dipped	3.73	4.80	5.0	4.8	3.5	3.6
	Distance 1 and Non-Dipped	4.20	5.18	5.6	5.2	4.0	4.1
	Distance 2 and Non-Dipped	4.13	4.80	5.7	4.8	3.7	4.1
	Distance 3 and Non-Dipped	3.85	4.50	4.9	4.5	3.8	3.8
	Distance 4 and Non-Dipped	3.50	4.65	4.9	4.7	3.3	3.4

For example, in the high school “dippers” taking “dipped” shots at distance 4, there were three potential outliers. Using the outlier-labelling rule, all three outliers were no longer considered outliers, confirmed through the extreme values list (see Table 5.5). Examining all of the outliers at the 1.5 multiplier level, and checking them at the recommended 2.2 multiplier level, yielded no outliers within the whole data set. As a result, assumption of outliers was not violated, and investigation for the last assumption of sphericity could occur.

5.2.4 Analysis of Shooter Type, Shot Type, and Distance Data and Interactions

A 2 Shooter Type x 2 Shot Type x 4 Distance mixed model ANOVA with repeated measures on the latter two factors was run using SPSS, with the skill level run in separate analyses (see tables 5.7 and 5.8). There was a significant main effect of shot type ($F_{1,17}$ = 27.608, p = 0.000), a main effect of distance ($F_{3,17}$ = 14.087, *p* = 0.000), and an interaction between shot type and distance ($F_{3,17}$ = 4.080, *p* = 0.012) for high school shooters (see table 5.8). There was a significant main effect of shot type ($F_{1,17}$ = 53.081, p = 0.000), a main effect of distance ($F_{3,17}$ = 16.102, *p* = 0.000), and an interaction between shot type and shooter type ($F_{3,17}$ = 10.995, *p* = 0.004) for university shooters. Pairwise comparisons of the distance effect indicated that shooting performance at distance 1 was better than distance 2, 3, and 4 (*p* = 0.005, *p* = 0.000, *p* = 0.000, respectively), while shooting performance at Distance 2 was better than distance 3 and 4 (*p* = 0.047, *p* = 0.001, respectively) in high school shooters. Pairwise comparisons of the distance effect indicated that shooting performance at distance 1 was better than distance 3, and 4 (*p* = 0.000, *p* = 0.000, respectively), while shooting performance at distance 2 was better than distance 3 and 4 (*p* = 0.047, *p* = 0.001, respectively) in university shooters (see figure 5.2). The interaction of shot type and distance in high school shooters, and the interaction of shot type and shooter type in university shooters were analyzed further to determine where the significant difference occurred. By combining shooter types and using a paired-samples t-test, the different distances were analyzed. This resulted in significant results for “dipped” (see table 5.7) shots occurring between distance 1 and 2 (p = 0.009); distance 1 and 3 (p = 0.002); distance 1 and 4 (p = 0.004). There was no significant difference between distance 2 and 3 (p = 0.141); distance 2 and 4 (p = 0.212); distance 3 and 4 (p = 0.365). This also resulted in significant results for "non-dipped" (see table 5.6) shots occurring between distance 1 and 2 (p = 0.002); distance 1 and 3 (p = 0.000); distance 1 and 4 (p = 0.000); distance 2 and 3 (p = 0.011); distance 2 and 4 (p = 0.000); distance 3 and 4 (p = 0.08). Graphically, as distance increased, accuracy decreased, with the exception of "dipped" shots' accuracy levelling off after distance 2 (see Figure 5.2).

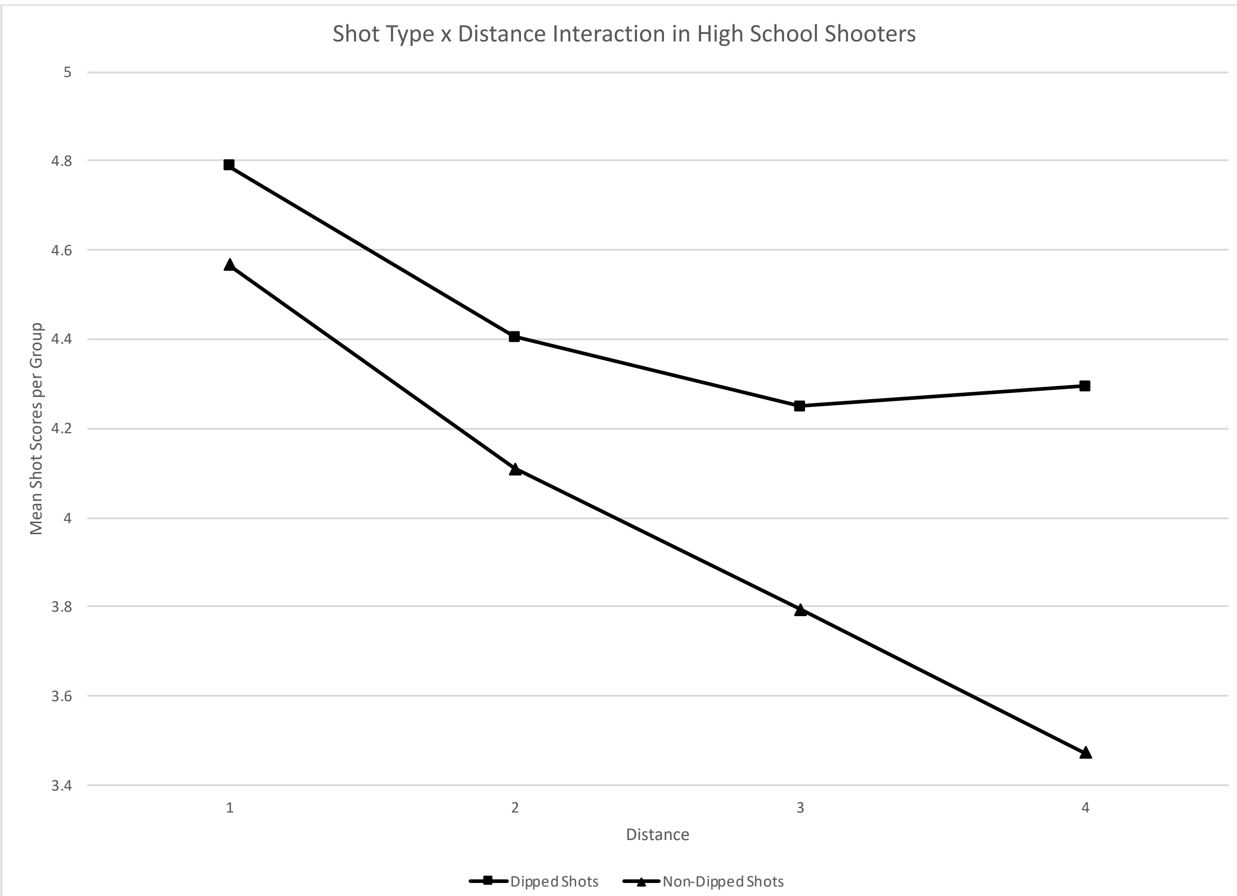

Figure 5.2. Shot Type x Distance Interaction in High School Shooters

Table 5.7

High School Shooters Paired t-test: Shot Type x Distance

		Paired Differences		
		t	df	Significance
Pair 1	DD1 - DD2	2..650	17	0.009
Pair 2	DD1 - DD3	3.493	17	0.002
Pair 3	DD1 - DD4	3.041	17	0.004
Pair 4	DD2 - DD3	1.110	17	0.141
Pair 5	DD2 - DD4	0.819	17	0.212
Pair 6	DD3 - DD4	-0.352	17	0.365
Pair 7	ND1 - ND2	3.291	17	0.002
Pair 8	ND1 - ND3	5.122	17	0.000
Pair 9	ND1 - ND4	7.658	17	0.000
Pair 10	ND2 - ND3	2.517	17	0.011
Pair 11	ND2 - ND4	5.777	17	0.000
Pair 12	ND3 - ND4	2.715	17	0.008

Note: DD1 would be "dipped", distance 1

By combining distances and using a paired-samples t-test, the different shooter types were analyzed. This resulted in significant results for “dippers” (see table 5.7) using the “dip” compared to the “non-dip” shooting motion (p = 0.000). This also resulted in significant results for “non-dippers” (see table 5.8) using the “dip” compared to the “non-dip” shooting motion (p = 0.023). While both types of shooters experienced an increase in accuracy when using the “dip” shooting motion, the “non-dippers” change in accuracy for non-dippers was smaller compared to “dippers” (see Figure 5.3).

Table 5.8

University Shooters Paired t-test: Shot Type x Shooter Type

		Paired Differences		
		t	df	Significance
Pair 1	All Dipper Dipped - Non-Dipped	8.620	9	0.000
Pair 2	All Non-Dipper Dipped - Non-Dipped	2.439	7	0.023

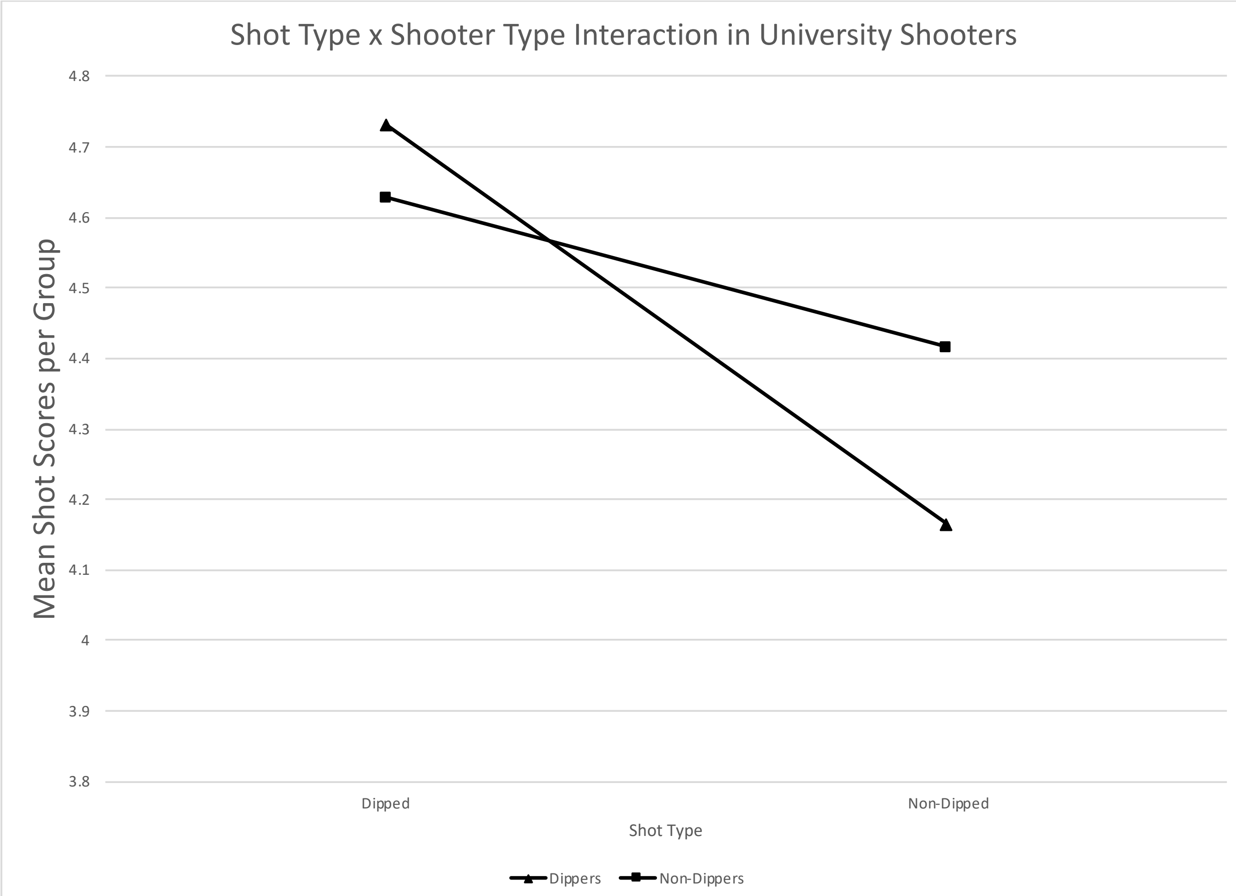

Figure 5.3. Shot Type x Shooter Type Interaction in University Shooters

Table 5.9
Main Effects

	Sphericity Assumed					
	Within-Subjects Effects	Type III Sum of Squares	df	Mean Square	F-Statistic	Significance
High School Shooters						
	Shot Type	5.054	1	5.054	27.608	0.000
	Shot Type * Shooter	0.135	1	0.135	0.735	0.404
	Distance	10.713	3	3.571	14.087	0.000
	Distance * Shooter	0.085	3	0.028	0.112	0.953
	Shot Type * Distance	1.346	3	0.449	4.080	0.012
	Shot Type * Distance * Shooter	0.037	3	0.012	0.113	0.952
University Shooters	Shot Type	5.408	1	5.408	53.081	0.000
	Shot Type * Shooter	1.120	1	1.120	10.995	0.004
	Distance	8.159	3	2.720	16.102	0.000
	Distance * Shooter	0.362	3	0.121	0.714	0.549
	Shot Type * Distance	0.137	3	0.046	0.448	0.720
	Shot Type * Distance * Shooter	0.047	3	0.016	0.155	0.926

Note: Bonferroni adjustment used for pairwise comparisons

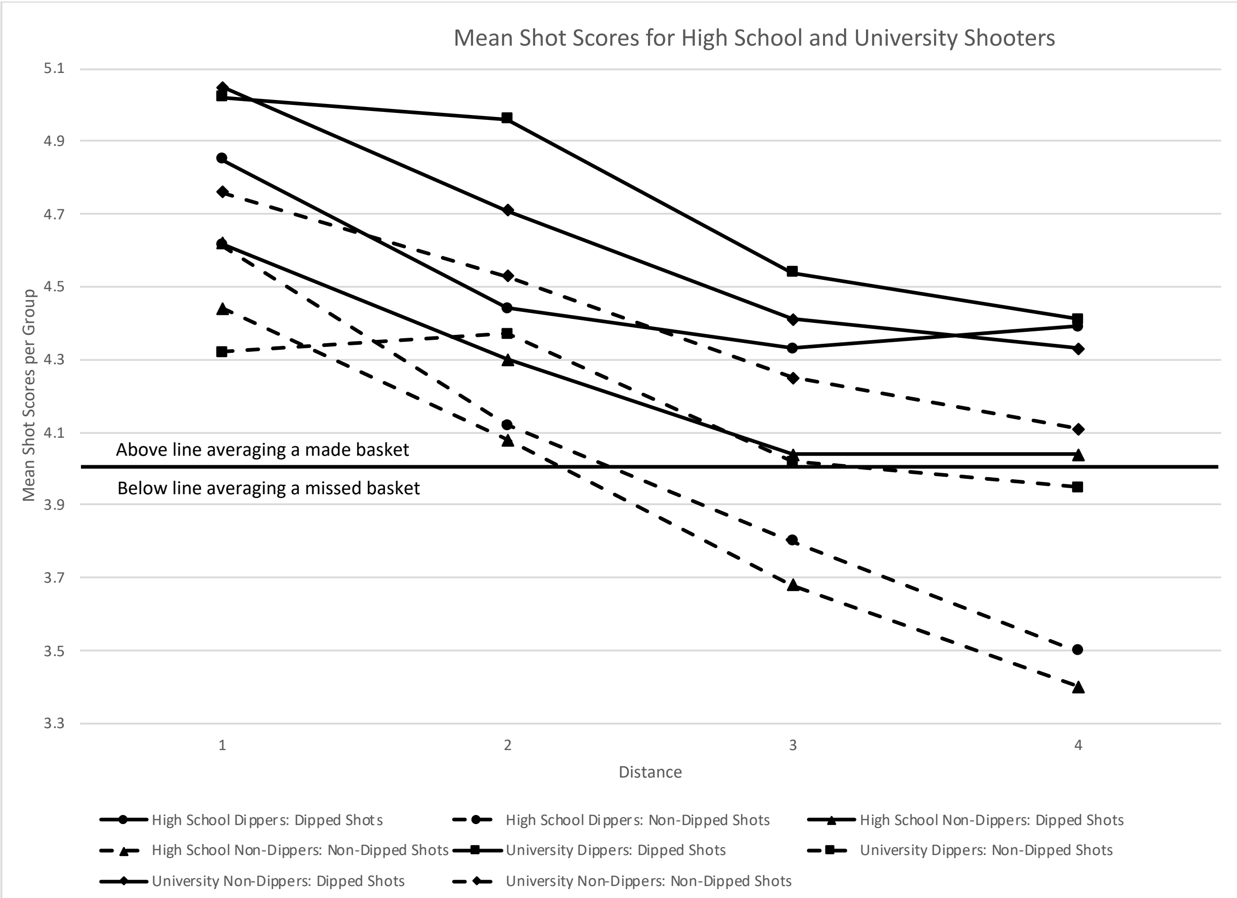

Figure 5.4. Mean Shot Scores on Shooter Types and Shot Types

Table 5.10

High School Interaction (Shot Type x Distance)

	Means		
	Distance and Shot Type	Mean	Standard Deviation
High School Shooters			
	Distance 1 and Dipped	4.8	0.52
	Distance 2 and Dipped	4.4	0.54
	Distance 3 and Dipped	4.3	0.39
	Distance 4 and Dipped	4.3	0.59
	Distance 1 and Non-Dipped	4.6	0.64
	Distance 2 and Non-Dipped	4.1	0.62
	Distance 3 and Non-Dipped	3.8	0.54
	Distance 4 and Non-Dipped	3.5	0.49

Table 5.11

University Interaction (Shot Type x Shooter Type)

	Means		
	Shot Type	Mean	Standard Deviation
University Dippers			
	Dipped	4.7	0.09
	Non-Dipped	4.2	0.12
University Non-Dippers			
	Dipped	4.6	0.13
	Non-Dipped	4.4	0.13

Chapter 6

DISCUSSION

6.1 Findings

6.1.1 Main Findings

As a result of this study, the “dip” increased the accuracy of both the “dipper” and “non-dipper” at the high school and university levels. The main goal of the study which was to test the effectiveness of using the “dip” in increasing the accuracy of the jump shot was supported by the findings of the present study. While the accuracy was increased, several other interesting interactions appeared, including high school shooting distance and shot type, and university shooter type and shot type.

As expected, distance had an impact on accuracy. In high school shooters, the accuracy at distance 1, being the shortest, was significantly different from all the other distances while distance 2 was also significantly different than all the other distances. University shooters had the same effect with distance, except for distances 1 and 2. This information suggested that those distance differences impacted accuracy to some degree. In basketball, accuracy will decrease as the shooter moves further from the basket (Okazaki, Rodacki, & Satern, 2015). The aforementioned significant differences supported this premise. The lack of significant difference from distance 3 to 4, as well as from distance 1 to 2 for university shooters, suggested that change in accuracy between the spots was not significant. Within high school shooters, there was an interaction between shot type and distance, which would address the first research sub-question: “Is the ‘dip’ distance-dependent?”. In the tests, the “dipped” shots at distance 2 and beyond were not statistically significant, and visually, showed a levelling off. This showed that the “dip” may reduce the effects that distance has on shooting accuracy, at least to the three-point line. For university shooters, there was an interaction between shooter type and shot type, which would address the second research question of “If basketball players naturally “dip” or do not “dip”, does it impact the accuracy of the shot when the “dip” is implemented?”. The results showed that the shot type impacted accuracy, particularly when using the shooting motion not already used by the player. “Non-dippers” experienced a smaller effect, based on visual representation, but both results were statistically significant. In summary, the main findings of this study were:

1. The “dip” was effective in increasing the accuracy of the basketball shot.
2. The “dip” was distance-dependent for high shooters, reducing the effect that distance had on accuracy.
3. The “dip” was effective in increasing the accuracy of the basketball jump shot for “dippers” and “non-dippers” of both elite high school and university skill levels.

6.1.2 Warm-up Shots

The warm-up shots were used to help create a baseline without any interference of instructions. Previous studies conducted by Podmenik and colleagues (2017), and Okazaki and Rodacki (2012) had participants conduct their own 10-minute warm-up. Other studies, such as Myrtaj (2012) and Liu and Burton (1999), either had no warm-up or told the participants to warm-up on their own. This regime may have caused some players to not be as accurate in shooting, particularly if no warm-up was done or there were no specific shots being taken during a warm-up. The usage of a baseline to demonstrate the accuracy of shooting data was not performed in other studies. Therefore, it was seen as unique with the present study. The shots provided a consistent and specific warm-up for each athlete to complete the study.

6.1.3 Distances

The specific distances were chosen to be as transferable as possible to a game situation. In Okazaki and Rodacki (2012), the distances used were 2.8m, 4.8m, and 6.8m. These were distances aimed at making the intervals equal. These distances would not be transferable for many players; for example, 6.8m is 0.05m behind the three-point line. In Liu and Burton (1999), shots were taken from distances between 3.048m (10 feet) and 4.572m (15 feet), or where the free throw line was located. In the current study, distance 1 was 3.125m, similar to Liu and Burton's (1999) study. At 3.048m, Liu and Burton (1999) reported that the accuracy was 85% for males. In the current study, the accuracy rate for 3.125m was 71% for high school shooters and 75% for university shooters. The difference could be based on the discrepancy in distance; however, the more likely contributor was the age of the shooters. In Liu and Burton (1999), the shooters ranged from 18 years to 32 years. The level of expertise of shooting, more basketball experience in most shooters, would seem to be the likely contributor in this case.

Podmenik and colleagues (2017) used three distances: 3.75m, 5.25m, and 6.75m, an increase of 1.5m at each distance. In their research, the authors discussed how their distances were longer because of the FIBA rule changes (Podmenik et al., 2017). The distances would roughly be half a lane length in front of the free throw line, halfway between the free throw line and the free throw circle, and the three-point line. These distances would be similar to distance 1, distance 2, and distance 4 in the present study. No accuracy data was reported in Podmenik and colleagues (2017), but shooters had no limit to shooting, as the researchers only measured made baskets. The most similar studies for comparison were Keetch and colleagues (2005), and Keetch, Lee, and Schmidt (2008). Both studies looked at distances starting at 9 feet (2.74m), increasing by 2 feet and 3 feet increments respectively, ending at 21 feet (6.40m).

For distances, the most important part of these aforementioned studies related to the generation of predicted success at any spot on the basis of individual regression analyses at the incremental spots. As a result, the predicted success rate of the shots at each distance of the present study would be approximately 84% at distance 1, 72% at distance 2, 63% at distance 3, and 58% at distance 4 (Keetch et al., 2008). In the present study, the actual success rate of the shots at each distance was 69.4% and 63.3% at distance 1, 51.1% and 51.1% at distance 2, 48.9% and 38.3% at distance 3, and 50.0% and 30.0% at distance 4 when high school shooters took "dipped" and "non-dipped" shots, respectively. The actual success rate of the shots at each distance for university shooters was 77.8% and 63.9% at distance 1, 70.6% and 61.1% at distance 2, 56.1% and 50.6% at distance 3, and 52.8% and 46.1% at distance 4 when taking "dipped" and "non-dipped" shots, respectively. Both sets of shooters had lower than predicted accuracy, likely due to the game-like shots being taken compared to the players in Keetch, Lee, and Schmidt (2008), who shot at their own pace. However, the university shooters, when taking "dipped" shots, most closely followed the predicted trend line. The lack of similarity was not a negative to the present study as the shots being taken were different, but it does create an idea of what would be expected if the situation was perfect, such as no defenders, and all the time needed to prepare the shot. In the present study, the distances were strategically chosen to reflect common shot locations in basketball, to help make the results more applicable to the game for coaches.

6.1.4 Research Design

When looking at the study set-up, there appeared to be a sampling bias from how the players were recruited. For the purpose and goal of the study, this made sense because it needed to be applicable to elite basketball athletes; therefore, novice basketball players were excluded. The protocol would be considered repeated-measures due to the players shooting both ways, "dipped" and "non-dipped". There were many benefits to a repeated-measures design specific to the present study; for example:

1. The study had greater statistical power as it could control for variability between subjects because the subjects completed both conditions.
2. Fewer athletes were needed because of the greater statistical power, resulting in a detection of an effect with fewer people. For example, if an independent group design needed 24 in each group, a repeated-measures design may only need 24 in the whole study.

There was one major effect that had to be taken into account for this type of design order effects. Order effects refer to the influence of the order of the conditions, rather than the conditions themselves (McLeod, 2007). For example, in the present study, if the shooters all shot from distance 1-4 in order, and shot all 10 "dipped" shots first, the order effect would be high, creating a skewed result in either direction. The principal investigator took several measures to reduce the order effect, in particular, the learning effect. The randomization of both the distance and the shot type ensured a reduction of the order effect. For example, some players started at distance 4, while others at distance 1. This also created randomization across the conditions and amongst the other shooters. For example, the likelihood of one shooter taking 10 "dipped" then 10 "non-dipped" shots would be balanced by the equal likelihood of another shooter taking 10 "non-dipped" shots then 10 "dipped" shots. Lastly, the recording process after each shot allowed a miniature break in order to reduce the order effect of the shot type. For example, the "dipper" taking a "non-dipped" shot, then a "dipped" shot, would not be influenced by how the first shot felt compared to the second.

The 30-second timed breaks between distances reduced the effect of fatigue on the shooter, particularly from the farther distances. Many basketball shooting studies (Okazaki et al., 2007; Suarez-Cadenas, 2016; Podmenik et al., 2017) did not use a repeated-measures design. This was partially because the other studies were not interested in the differences of components within the jump shot, but rather components that influenced it. For the present study, the repeated-measures design was essential to discovering the effectiveness of the "dip" for both shooter types.

6.1.5 6-point Scoring System

Within the basketball literature, several versions of scoring systems have been used, ranging from 2-point (Keetch et al., 2008), 4-point (Keetch et al., 2005; Keetch, Lee, & Schmidt, 2008), 5-point (Okazaki et al., 2007), and 6-point (Hardy & Parfitt, 1991; Lam, Maxwell, & Masters, 2009a; Lam, Maxwell, & Masters, 2009b). The 2-point scoring in Keetch, Lee, and Schmidt (2008) study dealt with made and missed baskets exclusively, leading to easier statistical analysis but less focus on shot quality. The 4-point scoring system used by Keetch and colleagues (2005) and Keetch, Lee, and Schmidt (2008) utilized a more descriptive series for the shots. For "swish" shots a 3 was given, shots that hit the rim before going in were given a 2, shots that hit the rim but did not go in were given a 1, and shots that missed completely were given a 0. This separated the made and missed components into two equal parts, "perfect make”/rim and in, and “perfect miss”/rim and out. It failed to demonstrate the difference in quality of a “make” when banking the shot off the backboard, resulting in an indetermination of quality. Okazaki and colleagues (2007) used a 5-point scoring system, defined by 2, 4, 6, 8, and 10 points, that ignored the effects of the backboard but rather divided made baskets that hit the rim. The authors gave 6 points for a shot that hit the rim many times before going in and 8 points for a shot that hit the rim once before going in. Ultimately, the 6-point system used by Hardy and Parfitt (1991) and subsequently by Lam, Maxwell, and Masters (2009a; 2009b) incorporated all the necessary parts to describe the results of a jump shot, “swishing” the shot, hitting backboard, hitting rim, “air-balling” the shot and whether it went in or not. If a player tried to “swish” the ball every time he shot, as in the present study, then realistically hitting the backboard should be valued less than hitting the rim.

Within the present study, the scoring system worked, having a mean range from 3.4 to 5.1 at the various distances and shooter types. Since the data was reasonably close, if shots were only made or missed, there would be less decipherability of the value of the “dip”. Furthermore, from a coach’s view, a good shot may not go in and a bad shot may go in. As a result, the use of more descriptors of the shot provides a better overall view of the shot by rewarding perfection, the “swish”. This 6-point scoring system served the purpose of the present study and captured the value of the “dip” in the jump shot, beyond the intrinsic value of the “make” or “miss”.

6.1.6 Release Time

Many coaches stated that the “dip” was too slow to use, and any player who used the “dip” ran the risk of getting his shot blocked (K. Schepp, personal communication, November 29, 2017). As a result, supplemental data collection on release time was collected. The question was not whether the “dip” took longer, but rather, was this distance significant enough to warrant not using the “dipping” motion. The difference was statistically significant, demonstrating that the “dip” was significantly slower. Within university shooters, the “dipped” shot time was on average 0.88 seconds compared to 0.73 seconds for “non-dipped” shot time while within high school shooters, the “dipped” shot time was on average 0.93 seconds compared to 0.78 seconds.

Waters (2017) investigated the release times of some premier NBA shooters in catch and shoot situations. The shooters, Kyle Korver, Klay Thompson, Buddy Hield, J.J. Redick, and Kevin Love, were chosen due to their ability to shoot the ball well and fast, and had release times of all types of shots, ranging from 0.76 seconds to 0.82 seconds. Several of these players were part of the NBA because of their ability to shoot the ball well and fast. Realistically the optimal release time would be longer for high school and university shooters. This average would further decrease when taking into account special cases like that of D21, who was not naturally a shooter, but rather a someone who only took short range shots in games and had release times around 1.3 seconds. The results in the present study demonstrated encouraging numbers for the use of the “dip” because of its effectiveness in increasing accuracy. Waters (2017) suggested that the range of ideal release time in high school and university shooters would be 0.70-0.85 seconds. When special cases, such as D21, were removed, the averages of the shooters in both groups fell within this proposed range. Furthermore Bazanov, Rannama, and Sirel (2015) found that the longest movement in the jump shot was not the “dip”, the “sitting down” phase, but rather the “catching” phase, when the player received the pass. The present study indicated that the “dip” increased accuracy significantly while the release time differences were statistically slower. However, Waters’ (2017) suggested that this release time difference was minimal, this would support that the “dip” increase of accuracy was more important when determining whether to use this type of shot.

6.1.8 Shot Arc

The arc of a shot was dependent on many factors including player height and release height. The NBA started to track shot arc using the SportVU player tracking system, allowing for analysis of different shooters (“NBA partners with Stats LLC”, 2013). Beuoy (2015) did an investigation of shot arc with two elite NBA players, Stephen Curry and James Harden. Stephen Curry is approximately 6’3”, and in the present study, there were four university shooters and two high school shooters listed at 6’3”. According to SportVU data, Curry’s average shot arc at the free throw distance was 58.1°, while a typical 6’3” player’s shot arc was 54.6°. Since no shots were taken at the free throw line in the present study, the averages of distance 1 (3.125m) and 2 (4.925m), resulting in the free throw line distance (4.025m) being half way between the two spots were taken. Thus, the average shot arc of 6’3” university shooters was 40.11° and the average shot arc of 6’3” high school shooters was 42.04°. Harden was approximately 6’5”, and in the present study, there were no university shooters and two high school shooters listed at 6’5”. According to SportVU data, Harden’s average shot arc at the free throw was 49.6°, while a typical 6’5” player’s shot arc was 53.4°. The average shot arc of 6’5” high school shooters was 32.16°. Looking at the data, Curry’s shot would be characterized as having a larger arc, and Harden’s would be seen as having a flatter arc. Compared to Curry’s the study shooters had approximately 17° less arc in their shot, while study shooters compared to Harden had 18° less arc in their shot. The consistency in the difference between the NBA shooter and the corresponding university and high school shooters is consistent with the idea that NBA shooters found a way to maintain a high release angle while not losing power, making them highly elite shooters.

In Çetin and Muratlı (2014), it was found that youth shooters had a shot arc of approximately 38°, similar to the 6’3” high school shooters. In Miller and Bartlett (1996), the average shot arc was deemed to be approximately 53°, significantly higher than the university shooters in the study. This data suggested that either the university shooters in this study may not have been as “elite” as initially thought, or when looking at the data, the age of the shooters in the present study were approximately four years younger than the ones in Miller and Bartlett (1996). In the case of the “dip”, shot arc did not seem to play a role in its effectiveness. Although, it could not be discounted, the effectiveness of the “dip” may lie in the consistency of the shooting motion, rather than a unique component, such as shot arc.

6.1.9 Interviews with the Players and Coach

The interviews with the players and coach provided experiential views of the “dip” and its effectiveness. Due to the coach’s extensive experiences overseas in professional basketball leagues, his views provided information from a coach’s perspective. It was beneficial to determine if the results, players, and the coach’s views all aligned or if there were gaps because it would help future shooting training tactics and concepts. The player interviews illustrated a common theme among the different groups, “dippers” and “non-dippers”. The debate for the “dip” was related to “rhythm” and resetting of the shooting motion for “dippers”, and quickness of release for “non-dippers”. The thoughts of the players demonstrated areas that coaches could address in the teaching process of the jump shot, particularly in younger athletes. The players, “dippers” and “non-dippers”, stated that personal preference determined how they shot, which was echoed by the coach. The coach emphasized that players utilized the “dip” if they needed strength to shoot the basketball. Within the present study, many of the taller players, particularly in university, were “non-dippers”, and many of the shorter players were “dippers”. However, the tallest player, at 6’8”, was a “dipper”. This anomaly suggested that either not all players utilized the “dip” for strength, or how strong the player was when he was younger dictated whether he “dipped”.

During an interview with Kevin Durant, he spoke about being 6’0”, and the tallest player on his team, in middle school. When he entered the NBA, he was 7’0”, and was considered a “dipper”. He gave credit to his godfather in making the decision to not play in the post, where the tallest players would play, but rather learn to dribble the ball and shoot (Ledbetter, 2014, June). He observed different great shooters such as Kobe Bryant and Tracy McGrady, who used a “dip”, and copied them (Ledbetter, 2014, June). Durant was coached in a way that treated him like a guard, even though he was the tallest player on the team. As a result, players’ heights should not determine how they should be taught to shoot, but rather, coaches should develop universal players.

Lastly, the influence of growth spurts would have a major impact on a player’s game. For example, in grade 9, Brandon Ingram, a current NBA player, was only 6’2” (Lou, 2017, September). He developed many qualities within his jump shot, including a “dip”, and grew nine inches over the next five years. Ingram was 6’11” in his rookie year in the NBA and regularly shot from the three-point line with improving efficiency (“Brandon Ingram”, 2017). Ingram demonstrated that a player with a promising future benefitted from a developed jump shot that included the “dip”. Statistically, the average height of an NBA point guard was 6’2”, with only 5% of the population being taller than that (Ledbetter, 2014, June). The height of a player in middle or high school should not dictate how the player learns to shoot (Canada Basketball, 2008). Both the aforementioned players were the same height during the 2017/18 NBA season but grew at very different paces. If players learned different skills, such as the "dip", early on in their basketball careers, their shooting skills may be different, but coaches should not limit a player's exploration into his shooting motion, as suggested by the players' interviews. The importance of the "dip" only worked, based on the responses, if the player felt comfortable using it, which could be trained through repetition (Ragan, 2014, October).

6.1.10 The "Dip"

The present study indicated that the "dipping" motion increased the accuracy of the jump shot when compared to "non-dipping". Higgins and Spaeth (1972) found a link between the consistency of a person's specific movements and accuracy, such as a shooting motion. However, as demonstrated by Schmidt and colleagues' (1979) impulse variability theory and Hatze's (1979) work on the variability of the neuromuscular system, their research data suggested that identical movement patterns were nearly impossible to achieve (Newell & Corcos, 1993). Within basketball literature, Vaughan and Kozar (1993), and Miller (2000) agreed that basketball shooting movements were not possible to replicate perfectly, attributing some of the variability with "late-stage" adjustments, those closer to the point of follow-through, and greater impulse generation. If a player were to shoot a ball from where he caught it, there would be an increase in movement variability because of the change in shot location each time. The "dip" was utilized by many successful shooters because it allowed them to reduce the variability of the start position of the jump shot, resulting in less need for "late-stage" adjustments, and better control of the needed impulse, thereby achieving the necessary release angle and velocity. According to many NBA shooters in today's game, Klay Thompson was the most proficient at reducing variability, much of it due to the utilization of the "dip" (Murphy, 2015, April). Based on the present study, the "dip" increases the accuracy of the jump shot. As a result, four important concepts should become the focus in order to understand what this means for training, how to implement the use of the motion, and its overall importance to the development of basketball shooting.

1. Within players aspiring to become professional basketball players, adding the "dip" would not guarantee a position on an NBA team. Ericsson, Nandagopal, and Roring (2009) suggested that the single most important component to sports performance was the activation of dormant genes achieved through intense, deliberate practice. As a result, training the "dip" would be important for shooters to increase their accuracy, and thus, their chances of improving. Many NBA shooters made deliberate practice of the "dip" part of their routine, resulting in gaining proficiency in reducing the effects of movement variability to increase success rates (Murphy, 2015, April). Understanding that players, like Stephen Curry, have gone through major transformations of their shooting motion would be the difference between trusting in the "dip" being added to a player's jump shot or not. As a high school shooter, Curry shot the ball low and by his hips (Ostler, 2013, March). He made the conscious adjustments to his jump shot, ranging from shooting above his head and using the "dip", rather than shooting straight from the hips, to better his chances of success. Now he is one of the best shooters in the league today, and possibly of all-time. Curry

had the genetics, his father Dell played in the NBA, but it was his deliberate practice that allowed the changes to lead to his success.

2. In the use of basketball analytics, the concept of expected values, how many points should be expected from a shot type, and the importance of farther shots were deemed important. Mashal (2016, March) demonstrated, through the analytics of expected points, that in 1979/80, the first year the NBA adopted the three-point line, the expected points for a two-point shot was 0.976 points per shot while a three-point shot was less at 0.840 points per shot. Conversely, during the 2014/15 NBA season, the expected points for a two-point shot was 0.970 points per shot while a three-point shot was more at 1.050 points per shot. These numbers illustrated both the focus, and importance of the three-point shot. Shea (2014) demonstrated that the catch and shoot situation compared to the off the dribble situation was more accurate, resulting in an effective field goal percentage, an adjusted field goal percentage to account for the three-point shot, of 52% on catch and shoot while 41% was made off the dribble in the 2013/14 season. According to the present study's data, as the distances increased, so did the relevance of the "dip" for improving accuracy. All of this combined created a need for an increase in accuracy. The "dip" was utilized in the catch and shoot, for the present study, at two-point and three-point distances, resulted in an increase in accuracy. One point to consider, prior to elite training of the different shots and the "dip", concerned what type of shooter had the ball. For example, if a player had a choice to pass to Ray Allen, the best shooter of all-time, or Bismack Biyombo, who shot 18.2% from three for his career, he likely should pick Ray Allen purely because

of his current abilities (Restifo, 2015, August). The “dip” would not immediately add to the expected points of a shot, but given time, it would add immense value to shots from farther distances, particularly three-point shots, due to the increased accuracy.

3. As the game of basketball progressed, the interest and importance of the ability to shoot the three-point shot was apparent. Beyond just the ability to shoot the three-point shot, the shooter had the ability to create space on the floor as his defender must stay closer to him, termed “gravity”, which was the tendency of a defender to be closer to certain areas of the court (Pelton, 2014, October). For example, the best shooters, the basketball, and the basket would have the strongest gravities, while a poor shooter at the three-point line would have the least. In work done by Kitaw (2017, October), it was found that an inverse relationship existed between percentage of wide three-point shots and how many three-point shots were made per game. This study suggested that the best three-point shooters force defenders to stay closer to them, opening up the floor for their teammates. Thus, by adding the “dip”, “non-dippers” could increase their “gravity” as they become more accurate. For example, Giannis Antetokounmpo, one of the best players in the NBA currently, demonstrated a more sporadic use of the “dip” and usually did not “dip” when shooting. Due to this habit, his defenders backed off from him, as far as standing on the free throw line when he has the ball. This closed up a lot of space for his teammates to operate and put more pressure on him to create a shot. If Antetokounmpo developed a more consistent shot, then he would elevate his game, but also impact his teammates’ games. The present study was focused on the actions of the jump shot, but Pelton

(2014, October) and Kitaw (2017, October) demonstrated a far more intrinsic value for the “dip”. By using the “dip”, a “non-dipping” shooter would become more of a threat to score the three-point shot, and by association, force defenders closer, opening spaces up for other teammates to increase their accuracy.

4. The training of the “dip” would become important, but as the present study demonstrated, the effects on accuracy were much greater for the high school shooters. These effects may be a result of a “scaling effect”, such that the influence on elite athletes were smaller the more “elite” they are considered. For example, a person just learning to shoot a basketball may experience an increase in accuracy when using the “dip”, compared to a Team Canada basketball player incorporating the “dip” into his jump shot. However, increases in accuracy would be experienced, as illustrated by the present study, they may just be less for the elite player. For example, a Team Canada basketball player within the study initially shot 62.50% using his regular “non-dipped” shooting motion, and increased it to 67.50% accuracy using the “dipping” motion, resulting in a few more points each game. Compound this with every “non-dipping” teammate increasing their accuracy slightly, then the team could add eight more points each game. Particularly in the NBA or NCAA, that would be the difference between a win and a loss. Within high school, the scaling effect may be more prevalent from player to player because of the diversity of skills, resulting in potentially eight extra points for a single player. Understanding that the “dip” would increase the accuracy of a player to different degrees was important, and should not

deter elite athletes from incorporating it into their jump shot, as it could have long-term positive effects on accuracy through the increase in field goal percentage.

However, one must recognize that the "dip" is used to create rhythm for the shooter. "Dipping" for the sake of "dipping", without understanding why the "dip" helps may be detrimental to the shooter's shot, much like a "non-dipper" having a broken "dip". This occurs because the "non-dipper" does not understand how the "dip" feels. As a result, comfort in the movement is hugely important for the progress of the player. Ultimately, the "dip" proves to increase accuracy, but how one uses the "dip" and how comfortable he is with the motion in a game will determine the overall success of the player.

6.2 Components of the Jump Shot

6.2.1 Vision during the Jump Shot

When looking at vision and its relation to the jump shot, there are several components of interest. For example, the concept of "quiet eye" has evolved from focusing on coordination and reflex to focusing on visual and cognitive skills (Kohn, 2015). When looking at basketball players like DeAndre Jordan, a highly athletic player, and Jamal Crawford, a highly skilled shooter, there are distinct differences. During the 2014/15 season, Jordan averaged approximately 39% on free throws while Crawford averaged approximately 90% (Kohn, 2015). Based on the initial idea of superior physical dexterity, both shooters should have similar accuracies, but with new eye-tracking technology, better shooters are efficient in focusing on the correct parts of the motion at the right time. The eyes provide the necessary data for the motor systems to execute the movement. In the case of the "dip", reducing movement variability would naturally reduce unnecessary focal points. For example, if the pass was not accurate, utilizing the "dip" would eliminate having to determine where the ball is in relation to the body.

Furthermore, influences from concepts like retinal defocus should also be reduced because of the reduction in movement variability. According to Nideffer's (1976) model, the attentional focus for shooting would be considered narrow and external, reducing the number of cues necessary to maintain accuracy. When using the "dip", the reduction in variables, such as similar shooting motion, could further reduce the number of cues needed, such as adjusting for the location of the release point, which would be important for reducing postural sway caused by global imposed optic flow, and retinal defocus, resulting in increased accuracy.

6.2.2 Distractors when taking a Jump Shot

Since basketball is seen as a sport that needs accuracy to be successful, the importance of addressing distractors is evident when looking at the results of a shot. Distractors, such as the crowd through global imposed optic flow, and defenders through lateral bias, can negatively influence the accuracy of a shooter, regardless of shooting motion. Balance is a key component to the success of a shooter when distracted, because of the reduction in postural sway in the case of the crowd, and extremity misdirection in the case of a defender. The important distinction to make is the difference between balance during the preparation of the shot, and balance while in the air. There are two key concepts when describing balance in the air: core stability, and lower body manipulation (Splash Lab, 2017). Using the core muscles will reduce excess movement in the air while spreading the feet will reduce the angular velocity generated by the player.

Within physics, the spreading of the feet would increase the moment of inertia, a player's resistance to increasing or decreasing rotation around an axis. When looking at angular momentum (L), caused by the shooter turning in the air in order to lead with his shooting shoulder, called the "turn", the angular momentum will be the product of the moment of inertia and angular speed (see equation 12),

$$\boxed{L = I\omega} \tag{12}$$

Angular Momentum

represented by I and ω, respectively. As a result, the greater the moment of inertia, the lower the angular speed, creating better control in the air, which is important when defenders and distractors attempt to disrupt the overall path of the shot from the shooter's hand to the basket. When looking at the shooters in the present study, many of them utilized some form of a "turn" in the air when shooting at farther distances, particularly the three-point line. The "turn" in the shooter's motion is more prominent in the player's movements when using the "dipping" motion resulting in better alignment with the basket, as well as higher accuracy (Splash Lab, 2017). The "dip" may allow for players to more consistently and quickly utilize the "turn", which would allow for stability in the air to be achieved quicker. Ultimately, the turn may be indirectly impacted by the "dip", creating stability in the air, reducing the effects of defenders and the crowd.

6.2.3 Training of the Jump Shot

Understanding the laws and theories to explain human and athletic movement is important for the development of both the player and the coach. When training a player, a coach will not explicitly discuss Fitts' Law and the Impulse Variability Theory, but rather apply the ideas to his practices. For example, the speed-accuracy tradeoff is important because the faster a player attempts to shoot, the less accurate he will be in the movement. As a result, a coach may suggest focusing on certain parts of the movement, intrinsically slowing the motion down.

Additionally, the concept of "especial skills" is important to understand in training a specific shot. The research focuses around the free throw not following the negative linear trend in shot accuracy compared to distance, because the shot is practiced so often (Keetch et al., 2005; Keetch, Lee, & Schmidt, 2008). While the jump shot is a variable shot, coaches could encourage players to take a specific shot, other than the free throw during practice breaks. For example, the coach has an offense that gets players open for corner three-point shots. Instead of practicing free throws, the players could be required to score a certain number of corner three-point shots first, which would be applying the "especial skill" effect to a shot that would not necessarily be practiced in such a way. However, based on Keetch and colleagues' (2005; 2008) research, this training tactic should drastically increase the accuracy of the shot, and reduce the effects of distance. Compound this training method with the findings of the present study of high school shooters reducing the effects of distance on accuracy when using the "dip", teams could become highly efficient at shooting. Ultimately, practicing the movements, such as the "dip", in efficient and deliberate ways should increase the accuracy of the jump shot.

6.2.4 Biomechanics of the Jump Shot

Knudson (1993) has made six suggestions for improvements in the biomechanical processes of the jump shot: staggered stance and a vertical jump, shooting plane, release height, release angle, coordination of the upper and lower body, and ball rotation. Each of these concepts plays a role in the efficient and proper movement of a basketball shooter. The staggered stance allows the shooting shoulder to lead towards the basket and maintain the verticality of the shooter's torso, reducing the need for a more exaggerated "turn" motion in the shot. Once the foundation of the shot is established, the shooting plane, release height, release angle, and coordination of the upper and lower body are easier to understand. The positioning of the shooting shoulder allows the shooter to follow-through within the shooting plane, allowing for a higher release point. Furthermore, the coordination of the player's limbs allows for better accuracy, in that the arm moves in the plane consistently the same way and the overall body motion is fluid. This consistency allows for better control of facets in shooting that are more conceptual in nature, like release height, release angle, and ball rotation. Based on observations by the principal investigator, these six components are best seen controlled by elite shooters who also utilize the "dip" in an effort to reduce movement variability, such as Ray Allen and Steph Curry.

For example, Sport Science (2011; 2015) uses many of the aforementioned concepts to investigate the accuracy of both Allen and Curry, seen as the purest shooters to have played the game according to the videos. When analyzing Allen, he is seen to have a release time of 0.73 seconds, a forearm position nearly vertical, a release angle consistently between 46° and 50°, a release point at the top of his jump approximately nine feet above the court, and a backspin that generates two ball rotations per second. Conversely, Curry is seen to have a release time of 0.40 seconds, a forearm position within 5° of vertical, a release angle consistently between 50° and 55°, and a release point of approximately 0.60 seconds before the height of his jump. Elite shooters have unique components to their shot but are consistent in how they do the motions. Both Allen and Curry are "dippers" and so, the movement variability is reduced. Subsequently, all of the biomechanical processes are better controlled despite the fact that neither shooter is actively thinking about their release angle or back spin, resulting in greater movement consistency. The intrinsic understanding of how each athlete moves is important to understand in training the “dip”.

6.2.5 Fitness for the Jump Shot

In today’s society, basketball training is encouraged by coaches and parents to achieve the next set of skills. As the athlete builds muscle and stamina, the rate of fatigue will be reduced. Training will determine the rate of fatigue that the athlete will experience. NBA trainer Rob McClanaghan chooses to train his athletes for approximately an hour and fifteen minutes each session with room for maybe one break (Fortier, 2017). McClanaghan’s method is a high intensity workout, focusing on shooting skills, which helps reduce the effects of fatigue on the players in high intensity and pressure situations. McClanaghan’s method is an example of how rigorous training sessions can be for high level basketball players. However, the efficiency of a player’s movement is a key contributor to the success of his jump shot (Fortier, 2017). The “dip” is an influencer in the reduction of fatigue effects by minimizing extraneous movements, which may become overemphasized when a player is experiencing fatigue.

6.2.6 Professional Athletes and the Jump Shot

Elite basketball athletes are at the pinnacle of their sport due to their ability to efficiently score with the ball. Many of these basketball players utilize the “dipping” motion, but to what degree they “dip” is unique. There are three general degrees to which players “dip”: chest, waist, and thighs (Nordland, 2018). Rick Penny, a shooting coach, is largely seen as the expert on the one-motion shooting concept (Penny, 2017). In his experiences, he describes the three set positions, defined as the position of the body and ball once the back swing of the shooting motion, or the “dip”, has stopped, as “head pause”, “catapult”, and “one-motion” (Penny, 2017; See Figure 6.1).

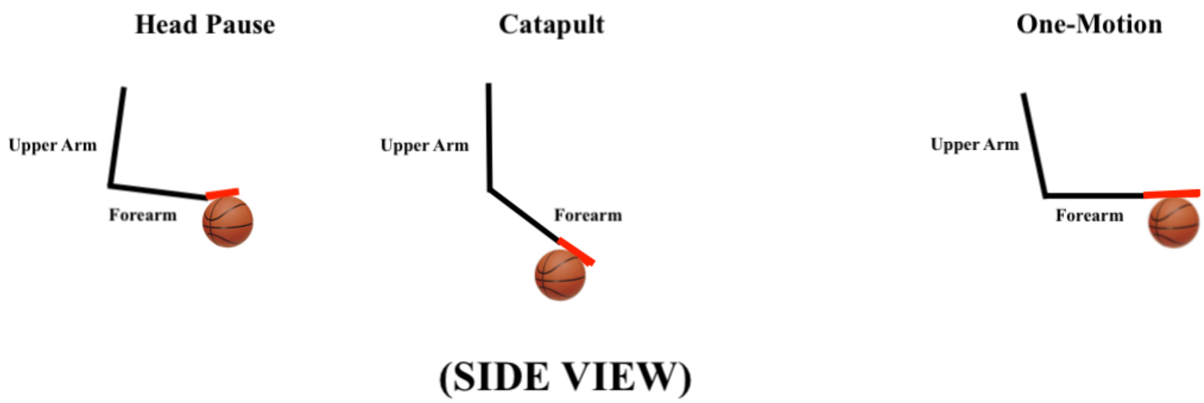

Figure 6.1. Three Set Positions after “Dipping” (Adapted from Penny, 2017).

In Penny’s work, he uses the three descriptions to describe arm and wrist angles, but can also be used to describe the “dipping” motions. However, he claims the one-motion has no “dip” in it. In his work, he provides examples of shooters who use each motion. For example, Kyrie Irving uses the “head pause” set position, Kevin Durant uses the “catapult” set position, and Steph Curry uses the “one-motion” set position. The only alteration to this model by the principal investigator was the one-motion set position because when watching video of Curry’s shooting motion, the “dip” ends around his chest, but his shooting hand has shifted to be in line with his forearm. In the “head pause” set position, the elbow angle is greater than 90° while the wrist angle will be slightly smaller than 90°. In the “dipping” motion, the ball will end up at the waist. In the “catapult” set position, the elbow angle is greater than 90° while the wrist angle will also be greater than 90°. In the “dipping” motion, the ball will end up at the thighs. Lastly, in the “one-motion” set position, both the elbow and wrist angles will be 90°. In the “dipping” motion, the ball will end up at the chest.

When looking at all three motions, the "head pause" and "catapult" set positions have two distinct movements while the "one-motion" set position has one distinct movement (see Figure 6.2). From this, it can be said that the "one-motion" set position should be the quickest of the three movements due to the shortest "dip", from shooting pocket to chest, and having one distinct motion. These three movements are utilized by the majority of NBA shooters, but as a younger athlete, these motions need to be experimented with as the athlete grows. Modifications and adjustments are important as the athlete develops unique nuances within his shot to increase his comfort and accuracy.

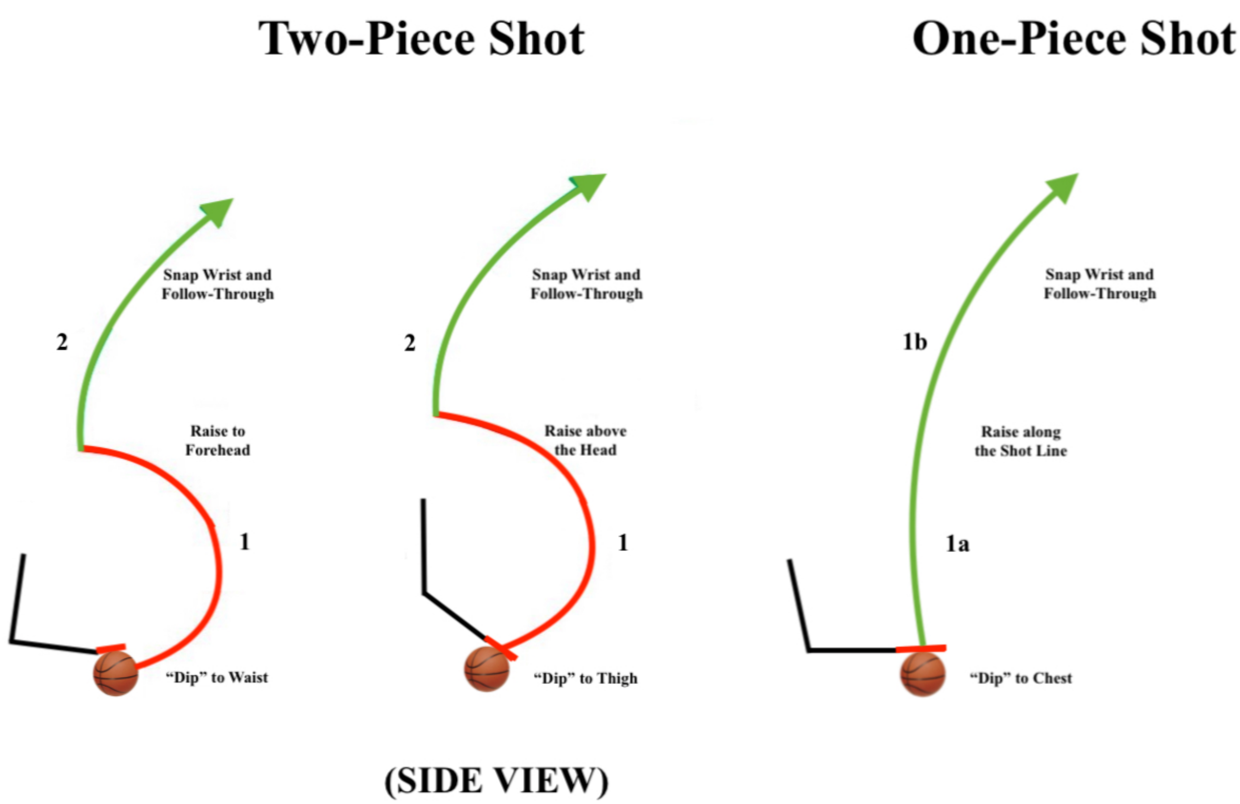

Figure 6.2. Shot Path of Each "Dipping" Motion (Adapted from Penny, 2017).

6.2.7 Incorporation of the "Dip" in the Jump Shot

Understanding the benefits of the "dip", its modifications, and what the present study says about the "dip" are essential, but the ability to incorporate the movement into a player's shooting skills will be of utmost importance. When looking at the present study, the larger effect of increasing accuracy using the "dip" occurs with the high school group. From this premise, one can predict that the "dip" effect can be substantially greater in middle school shooters because they are learning the techniques. Understanding the mechanics of shooting, such as the ones present in the study, are important, especially when the athletes are younger. If proper mechanics are taught, including the "dip", then the athlete will experience greater benefits in accuracy when they are in high school, and other higher levels. Furthermore, when the athletes get older, mental skills like mental rehearsal and self-talk can be taught to help refine the "dip". These skills are important because of the player's ability to practice the "dip" without a court or a basketball. Athletes will ultimately experience greater success in utilizing the "dip", resulting in better shooting skills along with higher recruitment offers. The training of the "dip" early on may potentially lead to a professional career, rather than ending after university. However, how the coach teaches these skills are imperative in an athlete's growth.

The coach must recognize the various potential ways to train an athlete, such as in Shoenfelt and colleagues (2002) research with four conditions: constant, variable front and back, variable combination, and variable random. The free throw is being trained in this case with the four conditions consisting of shooting only free throws, shooting shots two feet in front and behind the free throw line, shooting from the aforementioned three spots, and shooting from the corners of the free throw line and top of the key, respectively (Shoenfelt, 2002). The variable combination seems to be the most effective of the four conditions because it includes the free throw shots, being the criterion skill (Landin, Fairweather, & Hebert, 1993). When looking at training a shot or incorporating the “dip”, it is important to develop the skill, then train the movement using a variable practice to create the necessary habits. Ultimately, collaboration between researchers and coaches can drive the progress of effective training techniques in enhancing athletic skill growth (Berg, 1992), particularly with skills like the “dip”.

Chapter 7

CONCLUSION

7.1 Summary

The main focus of the present study was to investigate the effects of the “dip” on the performance of the basketball jump shot. To measure the effects 36 basketball athletes, from high school and university, were videotaped and analyzed using a 6-point scoring system. The scale was: 6 for a ‘clean’ basket; 5 for rim and in; 4 for backboard and in; 3 for rim and out; 2 for backboard and out; and 1 for a complete miss. Eighteen University of Manitoba male basketball players and eighteen elite high school basketball players from the 2017 Manitoba provincial team and 2016 Winnipeg Gold regional team participated in the study. Each player was told and shown what the “dip” looked like and what was required for it to be considered a “dip”. The protocol included 40 warm-up shots, used as a baseline, and 80 experimental shots, used for comparison. At the conclusion of the shooting protocol, the players were briefly interviewed for their thoughts on the “dip” and were told the principal investigator would go over their shooting form upon completion of defense of the study. This was done because the principal investigator wanted to see the effectiveness of the “dip” before teaching it or not.

A mixed model ANOVA with two repeated measures was used to assess the effects of the “dip” on the accuracy of a player’s jump shot from four pre-determined spots on the court. A statistical analysis of the data indicated “dipped” shots were more accurate than “non-dipped” shots for every shooter type at every distance for every skill level. Conclusions were then made on the effectiveness of the “dip” in increasing the accuracy of an elite basketball players jump shot.

7.2 Limitations

After the completion of the study, several limitations were identified:

1. Due to the fact that the principal investigator was flexible in meeting with the athletes, not all the shooting trials were done at the same time of day. This could have resulted in fatigue from shooting later in the day or shooting after a workout.
2. Ideally, both groups, “dippers” and “non-dippers”, would be represented by the same number of athletes. This was particularly evident with the high school group, which had only five “non-dippers” in the study.
3. Research assistants were not always available and so, the principal investigator had to do everything within the study, including maintaining a strict 30-second break between distances. This was maintained well but was difficult to accomplish.
4. In a perfect situation, all positional styles, ranging from a true centre to a playmaking guard would be represented to get a better sense of players and who benefitted the most from using the “dip”.

7.3 Conclusions

Based on the data collected from the present study, these were the main conclusions:

1. The “dip” increased the accuracy of all shooter types from every distance for both high school and university shooters.
2. The interviews with players and coaches indicated that rhythm was the main reason for using the “dip” and slower release time was the main reason for not using the “dip”.
3. Supplemental data collection indicated that the “dip” was slower than “non-dipping” but the release times were still within the prescribed release times of elite shooters.

7.4 Recommendations

The following are recommendations for future studies:

1. Additional research needs to be conducted on release times and other parameters specifically to provide a basis on whether to use the “dip” beyond accuracy.
2. Observation of games to determine when elite shooters use the “dip” and if accuracy improves in a game setting, compared to a laboratory setting, like the present study.
3. Additional research with younger athletes needs to be conducted to see if there is more value in using the “dip” earlier in a basketball player’s career.
4. Additional research with more elite shooters needs to be conducted to see if the scaling effect is outweighed by the amount of time needed to train the “dip” at a certain age.

7.4 Practical Implications

The present study included the following components:

1. The combination of “dipped” and “non-dipped” shots taken by each player.
2. The use of the player’s warm-up shots as a baseline to compare experimental shot accuracy.
3. The randomization of both shot types and distance orders to reduce the order effect.
4. The use of the 94fifty Smart Sensor basketball to track extra data on release time and shot arc.

Based on the present study, and the expertise of basketball coaches, the following suggestions are made to the coach and athlete interested in incorporating the “dip” into their jump shot:

1. Developing an analogy for the "dip" to help the motion become implicit will aid in the learning process (Masters, 2000).
2. Utilization of mental training, including mental rehearsal and self-talk, will be important in getting comfortable with the shooting motion.
3. Blocked practice, repetition of the same skill until some improvement is seen at specific distances, should be used until the skill feels natural (Ragan, 2014, October).
4. Random practice, practicing multiple skills in a random order with limited repetitions of the same skill, should be used to better retain the skill for long-term use (Ragan, 2014, October).
    a. NBA shooting coach Chip Engelland, famous for training Steve Kerr, the most accurate shooter in NBA history, suggested that block practice was best for those learning a new skill and random practice was best for those mastering a skill (Oliver, 2017). For example, if a player struggled to make 15% of his shots, random practice may not be ideal because the player had not experienced what a successful shot form felt like in a practice. Dave Love, another NBA shooting coach, demonstrated that it was important to make the shift to random practice at the right time to maximize the success of the shooter (Oliver, 2017).

Chapter 8

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Chapter 9

APPENDICES

Appendix A: Randomized Shooting List

Dipper or Non-Dipper

	Shot	Accuracy Score	Release Speed	Arc
Top lane line (2.95 m)	ND			
	ND			
	ND			
	ND			
	D			
	ND			
	ND			
	D			
	ND			
	ND			
	ND			
	ND			
	D			
	D			
	D			
	D			
	D			
	D			
	D			
	D			

Dipper or Non-Dipper

	Shot	Accuracy Score	Release Speed	Arc
Extra lane length (3.80 m)	D			
	D			
	ND			
	ND			
	D			
	D			
	D			
	D			
	D			
	D			
	ND			
	D			
	D			
	ND			
	ND			
	ND			
	ND			
	ND			
	ND			
	ND			

Dipper or Non-Dipper

	Shot	Accuracy Score	Release Speed	Arc
Top Free Throw Circle (5.85 m)	D			
	D			
	ND			
	D			
	D			
	ND			
	D			
	ND			
	D			
	D			
	ND			
	D			
	ND			
	ND			
	ND			
	D			
	ND			
	ND			
	D			
	ND			

Dipper or Non-Dipper

	Shot	Accuracy Score	Release Speed	Arc
Three Point Line (6.75 m)	ND			
	D			
	D			
	D			
	ND			
	ND			
	ND			
	ND			
	D			
	D			
	ND			
	ND			
	ND			
	D			
	D			
	ND			
	D			
	ND			
	D			
	D			

Appendix B: Shooting Coach Interview Questions

Interview with a Coach

Question #1: What kinds of player and coaching experience do you have?

Question #2: Why do you think players “dip”?

Question #3: Why is there is a variety of “dippers” and “non-dippers”?

Question #4: Which do you think is better for a good jump shooter or does it matter?

Question #5: Do you think it is possible to effectively teach players to “dip” or not?

Question #6: Any additional thoughts on the “dip”?

Appendix C: Quantitative Results

Baseline Testing: Paired-Samples t-test

A paired-samples t-test was conducted to compare the shot accuracy in the warm-up shots and experimental shots at each of the four shooting spots for the thirteen high school “dippers”, the five high school “non-dippers”, the ten university “dippers”, and the eight university “non-dippers” (see table 9.1).

Table 9.1
Baseline for Warm-Up Shots

		Warm-Up Shots		Experimental Shots				
	Distance	Mean	Standard Deviation	Mean	Standard Deviation	df	t	Significance
High School Dippers								
	1	6.77	1.17	7.31	1.55	12	-1.46	0.17
	2	5.85	1.34	5.23	1.69	12	1.60	0.14
	3	4.69	1.44	5.08	1.38	12	-1.10	0.29
	4	4.62	2.02	5.38	2.22	12	-1.95	0.08
High School Non-Dippers								
	1	6.20	1.48	6.60	2.51	4	-0.67	0.54
	2	5.20	2.59	5.20	3.56	4	0.00	1.00
	3	4.00	1.58	3.40	1.52	4	1.18	0.31
	4	3.40	1.95	3.20	1.64	4	0.27	0.80
University Dippers								
	1	7.30	1.25	7.70	1.57	9	-0.77	0.46
	2	6.90	1.52	7.60	1.65	9	-1.91	0.09
	3	5.50	1.27	6.00	1.25	9	-1.46	0.18
	4	5.40	1.71	5.40	1.26	9	0.00	1.00
University Non-Dippers								
	1	7.75	1.39	7.25	1.75	7	0.73	0.49
	2	6.38	0.92	6.63	2.20	7	-0.31	0.76
	3	5.00	1.51	5.50	1.69	7	-1.87	0.10
	4	4.38	1.69	5.00	2.56	7	-1.17	0.28

Due to all of the p-values being greater than 0.05, the set significance level, the null hypothesis could not be rejected.

Appendix D: Qualitative Results

Interviews with the Players

After the shooting protocol was completed, each pair of players was asked one question individually, based on their shooter type. If the shooter was a “dipper”, he was asked, “Why do you think you use the ‘dip’?”. If the shooter was a “non-dipper, he was asked, “Why do you think you don’t use the ‘dip’?”. The question was asked to get a player’s perspective, the one taking the jump shot, to better understand the role of the “dip”. Percentage reporting was done with this data. Within the “dippers”, there were a few common statements.

1. 69.6% of “dippers” stated that the “dip” got them into rhythm and a more fluid jump shot.
2. 47.8% of “dippers” stated that they thought the “dip” gave them more power in their legs.

A comment made by a few “dippers” was interesting. Two players stated that they felt it was a “bad habit” and should not be “dipping”. One also mentioned that the previous university he played at in NCAA Division 1 basketball, spent many practices attempting to get him not to “dip”. The team believed it left more room for error. Three other players stated that it was dependent on position, suggesting that the “big men” did not “dip”, but guards did “dip”. Lastly, one player mentioned that a bad pass was negated by the “dip”, through the resetting of the shooting motion. Within the “non-dippers”, there were a few common statements.

1. 84.6% of “non-dippers” stated that not “dipping” allowed them to get their shot off more quickly.

2. 38.5% of “non-dippers” stated that they felt they were more balanced when not “dipping”.

Two “non-dippers” started basketball as “dippers” but were forced to change by coaches who thought the “dip was a pointless part of the jump shot. One player stated that there was less variation in the shooting motion if he did not “dip”. Another player mentioned that the “dip” was dependent on the player. Lastly, one player stated that “dippers” were not as confident with their shot because they need to shoot in rhythm. These responses help address the divide between “dippers” and “non-dippers”. There seemed to be small pieces related to technique, but the biggest influence appeared to be coaches and their philosophies.

Interview with a Coach

After the present study was completed, the University of Manitoba Bisons shooting coach was contacted to answer seven questions. A summary of his thoughts on the “dip” were provided:

1. What kinds of player and coaching experience do you have?

   The coach initially started his playing career in Serbia for two separate teams: Crvena Zastava, for the Pioneer, Cadets, and Junior levels, and 21 Oktobar, for the semi-professional level. The coach also ran coaching clinics in Borsko Jezero, Serbia for Košarkaški klub Bor RTB. He later moved to Manitoba and coached at various levels, including high school, college, and university. The global experience of the coach, and his particular interest in developing shooting abilities within players, made him an ideal coach to speak to about the “dip”.

2. Why do you think players “dip”?

In his discussion of the “dip”, he suggested that when players first started to play basketball, if they were taller, they likely would not “dip”, and if they were smaller, they likely would “dip”. This was because of the relative strength between the players; for example, two players at age eleven may have had different strength levels if one player was 5’6” and the other is 6’4”. The 6’4” would be encouraged not to “dip” and may not because he was strong enough to shoot without extra power. Conversely, the 5’6” player would be encouraged to shoot from farther out, where he would not get blocked easily, but would need the “dip” to generate enough power.

3. Why is there a variety of “dippers” and “non-dippers”?

   He reiterated that the variety would be due to the relative strength levels of the players when they first started playing basketball. It would be based on not only height, but strength. For example, if a 6’6” player could not shoot very far, he may develop the “dip” to gain power, even though he was tall.

4. Which do you think is better for a good jump shooter, “dip”, no “dip”, or does it matter?

   The coach addressed this question by saying that it did not matter whether a player “dips” or not, but rather that personal preference should dictate whether the “dip” was used. Coaches should teach through the players preference rather than making the decision for them.

5. Do you think it is possible to effectively teach players to “dip” or not?

   The coach suggested that a player should be taught positional skills, in that bigger, taller players should learn not to bring the ball down; whereas it would not be as pertinent for longer range shooters because of the proximity to the basket. The advantage of the approach of keeping the ball high diminished the farther the player was from the basket (S. Komlenovic, personal communication, September 3, 2017).

6. After knowing the results of the study of the “dip” effectively increasing accuracy, would that change your opinions of the “dip”?

   After learning of the results of the study, the coach stated that his thoughts of the “dip” did not change because the players he trained throughout the years had gone through high school already. The only way to improve their shooting was to make small adjustments, rather than break down the player’s shooting motion. For example, changing a “non-dipper” to a “dipper” would be too difficult, and the effect on initial shooting numbers would be adverse to the team’s goals of winning immediately.

7. Any additional thoughts on the “dip”?

   The way to change a shooting motion would be to start training players when they first started playing basketball. This way, when they entered university levels, the “dip” would be seen as a part of their shooting motion.

The coach supported the results, but believed that the training of the “dip” needed to occur in middle school or junior high, not in high school or university.

Appendix E: Secondary Dependent Variables

Release Time

One of the biggest issues that many coaches had with the “dip” was that they believed it was too slow to get the player’s shot off in time. Using the 94fifty Smart Sensor basketball, release time was collected to help determine if the difference in release time between “dipping” and “not dipping” was statistically significant (see table 9.2).

Table 9.2
Summary of Means in Release Time Data

	Means		
	Distiance and Shot Type	Mean	Standard Deviation
High School Dippers			
	Distance 1 and Dipped	0.93	0.140
	Distance 2 and Dipped	0.95	0.153
	Distance 3 and Dipped	0.93	0.143
	Distance 4 and Dipped	0.93	0.155
	Distance 1 and Non-Dipped	0.78	0.138
	Distance 2 and Non-Dipped	0.78	0.135
	Distance 3 and Non-Dipped	0.80	0.145
	Distance 4 and Non-Dipped	0.81	0.139
High School Non-Dippers			
	Distance 1 and Dipped	0.91	0.069
	Distance 2 and Dipped	0.89	0.155
	Distance 3 and Dipped	0.91	0.049
	Distance 4 and Dipped	0.90	0.044
	Distance 1 and Non-Dipped	0.73	0.122
	Distance 2 and Non-Dipped	0.72	0.157
	Distance 3 and Non-Dipped	0.76	0.147
	Distance 4 and Non-Dipped	0.78	0.099
University Dippers			
	Distance 1 and Dipped	0.86	0.071
	Distance 2 and Dipped	0.85	0.081
	Distance 3 and Dipped	0.85	0.090
	Distance 4 and Dipped	0.85	0.090
	Distance 1 and Non-Dipped	0.69	0.083
	Distance 2 and Non-Dipped	0.70	0.091
	Distance 3 and Non-Dipped	0.72	0.119
	Distance 4 and Non-Dipped	0.71	0.090
University Non-Dippers			
	Distance 1 and Dipped	0.91	0.072
	Distance 2 and Dipped	0.89	0.125
	Distance 3 and Dipped	0.92	0.078
	Distance 4 and Dipped	0.93	0.093
	Distance 1 and Non-Dipped	0.74	0.083
	Distance 2 and Non-Dipped	0.80	0.114
	Distance 3 and Non-Dipped	0.80	0.119
	Distance 4 and Non-Dipped	0.81	0.107

Since the assumptions were held in the main investigation, a mixed model ANOVA with two repeating measures was used. After running the analysis, the results were significant for both groups in shot type and university shooters had an interaction with shot type and distance (see table 9.3).

Table 9.3
Mixed Model ANOVA on Release Times

		Sphericity assumed				
	Source	Type III Sum of Squares	df	Mean Square	F	Significance
High School Shooters						
	Shot Type	0.643	1	0.643	62.867	0.000
	Distance	0.009	3	0.003	0.882	0.457
	Shot Type * Distance	0.009	3	0.003	2.017	0.124
University Shooters	Shot Type	0.654	1	0.654	111.606	0.000
	Distance	0.013	3	0.004	1.845	0.152
	Shot Type * Distance	0.015	3	0.005	4.942	0.005

By combining shooter type and running a paired-samples t-test, the interactions with shot type and distance within university shooters could be better understood. This resulted in significant results for “non-dipped” (see table 9.4) shots occurring between distance 1 and 2 (p = 0.025); distance 1 and 3 (p = 0.022); distance 1 and 4 (p = 0.009). There was no significant difference between any of the other distances in regards to release time.

Table 9.4
University Shooters Release Time Paired t-test: Shot Type x Distance

		Paired Differences		
		t	df	Significance
Pair 1	RTDD1 - RTDD2	1.229	17	0.118
Pair 2	RTDD1 - RTDD3	0.173	17	0.433
Pair 3	RTDD1 - RTDD4	0.030	17	0.489
Pair 4	RTDD2 - RTDD3	-1.119	17	0.140
Pair 5	RTDD2 - RTDD4	-1.398	17	0.090
Pair 6	RTDD3 - RTDD4	-0.237	17	0.408
Pair 7	RTND1 - RTND2	-2.120	17	0.025
Pair 8	RTND1 - RTND3	-2.191	17	0.022
Pair 9	RTND1 - RTND4	-2.618	17	0.009
Pair 10	RTND2 - RTND3	-0.787	17	0.221
Pair 11	RTND2 - RTND4	-1.024	17	0.160
Pair 12	RTND3 - RTND4	-0.044	17	0.483

Note: RT refers to "release time" and DD1 would be "dipped", distance 1

Each of the results suggested that “dipping” was slower than “non-dipping”. The significant difference occurred as the release speed was significantly quicker at distance 1 compared to the release speed at distances 2, 3, and 4. This would also suggest that the release time could influence decisions to use the “dip”, despite effectiveness in increasing accuracy.

Shot Arc

Shot arc was tracked, also using the 94fifty Smart Sensor Basketball, to see if there was a significant difference between “dipped” and non-dipped” shots, directing researchers to a potential reason why “dipping” was effective (see table 9.5).

Table 9.5
Summary of Means in Shot Arc Data

	Means		
	Distiance and Shot Type	Mean	Standard Deviation
High School Dippers			
	Distance 1 and Dipped	31.82	5.67
	Distance 2 and Dipped	46.71	5.90
	Distance 3 and Dipped	52.85	5.44
	Distance 4 and Dipped	54.89	4.95
	Distance 1 and Non-Dipped	32.17	4.87
	Distance 2 and Non-Dipped	47.55	5.47
	Distance 3 and Non-Dipped	52.59	5.48
	Distance 4 and Non-Dipped	54.78	4.15
High School Non-Dippers			
	Distance 1 and Dipped	34.58	6.76
	Distance 2 and Dipped	50.22	6.88
	Distance 3 and Dipped	54.96	4.87
	Distance 4 and Dipped	56.44	5.33
	Distance 1 and Non-Dipped	33.94	6.57
	Distance 2 and Non-Dipped	49.16	5.55
	Distance 3 and Non-Dipped	53.84	4.79
	Distance 4 and Non-Dipped	56.10	4.21
University Dippers			
	Distance 1 and Dipped	35.06	5.97
	Distance 2 and Dipped	47.43	4.60
	Distance 3 and Dipped	51.29	3.16
	Distance 4 and Dipped	54.41	3.53
	Distance 1 and Non-Dipped	36.22	7.57
	Distance 2 and Non-Dipped	47.20	4.11
	Distance 3 and Non-Dipped	51.36	3.43
	Distance 4 and Non-Dipped	54.50	3.29
University Non-Dippers			
	Distance 1 and Dipped	34.64	3.17
	Distance 2 and Dipped	46.36	2.48
	Distance 3 and Dipped	49.69	2.37
	Distance 4 and Dipped	53.20	2.19
	Distance 1 and Non-Dipped	34.28	2.77
	Distance 2 and Non-Dipped	46.73	1.97
	Distance 3 and Non-Dipped	50.76	2.12
	Distance 4 and Non-Dipped	53.98	1.95

Another mixed model ANOVA with two repeated measures was run with shot arc data. The results showed that there was no statistically significant increase with shot arc while using the "dip" or "non-dip" (see table 9.6). However, there was a main effect of distance. This suggested that shot arc increased as distance increased.

Table 9.6

Mixed Model ANOVA on Release Times

		Sphericity assumed				
	Source	Type III Sum of Squares	df	Mean Square	F	Significance
High School Shooters						
	Shot Type	2.449	1	2.449	0.763	0.395
	Distance	8924.275	3	2974.758	217.916	0.000
	Shot Type * Distance	1.557	3	0.519	0.241	0.867
University Shooters	Shot Type	4.802	1	4.802	1.150	0.300
	Distance	7325.332	3	2441.777	222.946	0.000
	Shot Type * Distance	1.226	3	0.409	0.233	0.873

This would suggest that shot arc was not a contributor to the effectiveness of the "dip".

Appendix F: Pilot Study

Protocol of Pilot Study

A pilot study was conducted at the Canadian Mennonite University (CMU), using three athletes from the men's basketball team, with verbal consent provided. These three players were recruited through a larger meeting with the CMU team. These players were curious about their jump shots and wanted to see if the "dip" was already a part of their shot. This preliminary study was done to better influence the direction of the research in an effort to show the potential for results within the project, as well as to see whether a distance existed when "dipping" became more advantageous than "non-dipping".

Two cameras were used, one for the front view, and one for the side view of the jump shot, to record the activity allowing for later analysis. The side view camera was placed along the gym's basketball court sideline, perpendicular to the shooter at each of the five spots. The front view camera was placed directly underneath the middle of the backboard, with the basket directly in front of it. The passer was then placed on either side of the camera, depending on the handedness of the shooter; for example, if the shooter was right handed, the passer would be on the left side of the camera. The athletes were instructed to take ten jump shots at each of the five marked spots, with the ball being passed to them by a teammate (see Figure 9.1). These spots were the "no-charge semi-circle" (1.425m), the top lane line from the basket (3.125m), an extra lane line length from the free throw line (4.925m), the top of the free throw circle (6.025m), and the three-point line (6.75m).

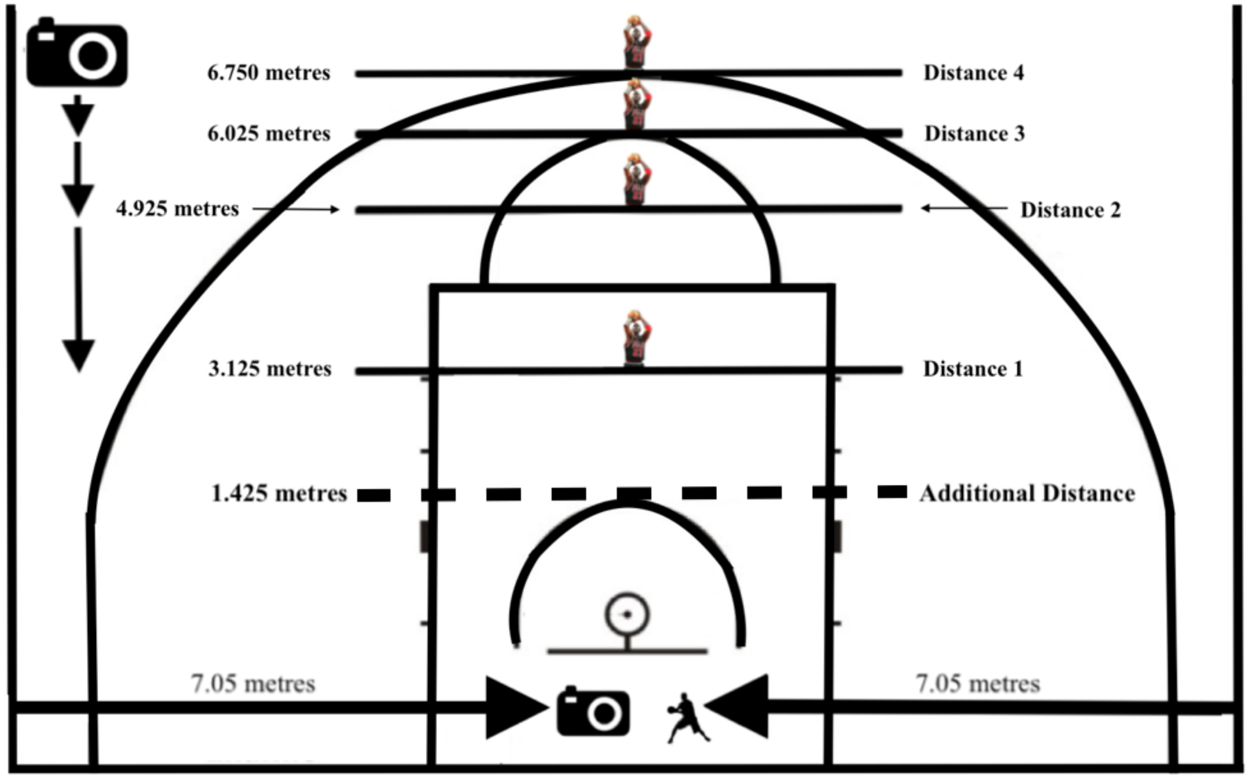

Figure 9.1. Pilot Study Shot Distance Markings on FIBA Court Diagram (Adapted from “FIBA Rules”, FIBA Central Board, 2014).

This sequence was followed as both a warm-up, but also to identify whether the player was naturally a “dipper” or “non-dipper”, and whether they changed as they progressed away from the basket. Once the players were warmed-up, the protocol was explained. Before the players could take any more shots, the definitions of “dipping” and “non-dipping” were explained and demonstrated so the players knew what they could and could not do for each shot. The “dip” occurred when the ball dropped below the shooter’s shooting pocket and a “non-dip” occurred when the ball stayed at the set point, above the shooting pocket. Each player then repeated the ten jump shots from each spot, but this time they were instructed whether to “dip” or “no dip”. The passer remained in front of the player, and passed the ball as if in a game situation. Before the ball was passed, the researcher would say either "dip" or "no dip", with five of each shot at every distance. At the end of each player's trial, the results were tallied for overall field goal percentage of "dipped" versus "non-dipped" shots, as well as the quality of the shot using a 6-point scale developed by Hardy and Parfitt (1991). The scoring system consisted of 5 for a 'clean' basket; 4 for rim and in; 3 for backboard and in; 2 for rim and out; 1 for backboard and out; and 0 for a complete miss (Hardy & Parfitt, 1991).

Each of the players—denoted JH2, NB5, and JN9—exhibited different shooting styles. JH2 was a "non-dipper" until he reached the third spot, just beyond the free throw line, where he began to "dip". NB5 was a "dipper" throughout his trial, and JN9 was a "non-dipper" throughout his trial. After review of the video, it showed that each player had generally increased his shot percentage while "dipping", including the "non-dipper". JN9, the "non-dipper", had the largest increase in shooting percentage with an overall increase of 32%, while JH2 experienced an increase of 16%, and NB5 saw an increase of 10%. Furthermore, there seemed to be no difference, or a relatively small difference between "dipped" and "non-dipped" shots up to the third spot. This data suggested that the line where an advantage to "dip" existed was between the third and fourth spot. Ultimately, the sample size was too small to make any concrete inferences, but it did supply a positive view of the work ahead, and added testing structure to the future research project.

Differences between the Study and Pilot Study

By conducting the pilot study, unforeseen problems and better ideas were addressed to help improve the study. A few adjustments were influenced by subsequent research for the literature review of the basketball jump shot, and others were seen as unnecessary. These adjustments included:

1. Demographic information: In the pilot study, no demographic information was taken. In the study, basic demographic information was provided by the player such as height, age, years playing basketball, skill level, and handedness. This helped supply an overview of the sample population.
2. The adjustment of the front view camera location: In the pilot study, the camera was directly underneath the basket with the passer to either side of it. When reading the literature, this would have created a lateral bias for the shooters. As a result, the camera and passer were placed on either side of the basket, exactly 7.05m from the sidelines. This reduced the lateral bias effect on the shooter.
3. The addition of ten more shots at each spot: In the pilot study, the shooters were required to take ten shots at each spot, five "dipped" and 5 "non-dipped" shots. Due to the small amount of shots, there was a significant chance of one missed or made shot affecting the overall results of the study. As a result, ten additional shots were added so that the shooters took ten "dipped" and 10 "non-dipped" shots. The shot amounts were the same used by Viggiano and colleagues (2014), 80 shots and 20 shots from each condition or distance. The additional shots created a more accurate representation of each shooter's abilities and give a better idea of whether the "dip" was effective.
4. The removal of the first shooting spot: In the pilot study, there were five shooting spots with the first being at the "no-charge semi-circle" (1.425m). The shooters collectively scored 29 out of the 30 shots at this spot, for a 96.67% scoring rate. It

was deemed that at this distance, technique would have little impact on shooting accuracy, especially in the elite basketball group that was the focus of the study.

5. The warm up shots used as a baseline: In the pilot study, the warm up shots were not recorded, but taken only as a way to get the shooter ready for the study. The warm up shots for the actual study were used as a baseline to confirm, using a paired-samples t-test, that the experimental shots did not deviate from the shooter's baseline. This alteration supported the experimental shots as an accurate representation of the shooter's abilities at each distance.
6. Hardy-Parfitt 6-point scoring system: In the pilot study, the Hardy-Parfitt 6-point scoring system was used, with the scoring range being from 0-5. In the study, the scoring system was adjusted so that it was from 1-6, but still maintaining the 6-point aspect. The change was made to eliminate a 0, reducing the negative view of a "complete miss" for the shooters.
7. Added tracked material and the use of the smart basketball: In the pilot study, the 6-point scoring system was the only piece being tracked. In the study, the use of the 94fifty Smart Sensor Basketball allowed for two other components to be tracked, release time and shot arc. These components, while not the focus of the study, helped provide extra information as to why the "dip" was effective or not.
8. Player identification: In the pilot study, the players were identified by their initials and jersey number. In order to maintain confidentiality, the players in the study were simply labelled "D" or "ND" for "dipper" or "non-dipper" and what number of shooter they were in the study. For example, the sixth "dipper" of the study was "D06".