The Secret Behind Professional Basketball Players' Shooting

Body Paragraphs Page Count: 16
Appendix & Bibliography Page Count: 15

Introduction

As a member of the school's basketball team, I have a problem shooting consistently during the game. When I shoot, I can feel my shooting form changing slightly every time. Even though I practice every week, my shot has not improved significantly.

As I watched many NBA games, I have noticed that many NBA players have been attempting shots beyond the 3-point line, and this type of shot is often called "deep 3s" which means shots that have been taken beyond the 3-point arc. Currently, Damian Lillard is one of the leading players who is shooting deep 3s often. He has made 45.1% of his 3-point shots during the 2020~2021 NBA season which is above league average (36.7%) (*Damian*, 2021) (*NBA*, 2021). The beauty of Damian Lillard's basketball shot is that he is shooting in one motion. A one-motion shot is a type of basketball shot that is very quick and efficient (Penny, n.d.). Unlike a two-motion shot, the one-motion shot does not have a bending motion while shooting; therefore, the ball does not lose its momentum and the releasing time of the ball is quicker (ibid) (figure 1).

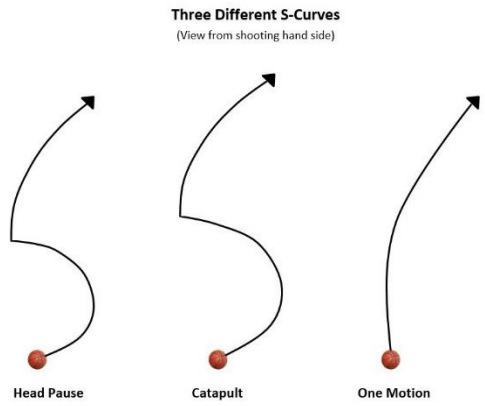


Figure 1 – One motion vs two motion

I have observed that most basketball players shooting hand has a repeating ascending and descending motion while shooting. Therefore, for this investigation, I will compare my shooting hand motion with that of Damian Lillard, a professional basketball player, to find the main problems with my shooting motion. To achieve this, I will apply my knowledge of trigonometric graphs, geometric transformation, trigonometric R method, and root mean square error (RMSE).

Research Question

How is my shooting motion different from Damian Lillard's (a professional basketball player) and what should I focus on to improve it?

Shooting Motion

The shooting hand plays a large role during shooting a basketball. Although the lower body movement is also important, producing 75 to 80% of the power, the shooting hand motion determines everything including the shooting arc, direction, and spin of a ball (*The Stance*, n.d.). Therefore, it is necessary to understand how shooting hand moves to shoot accurately.

However, to study the shooting hand motion in more detail, it should be isolated from lower body movement. This is because the shooting hand moves along with the knee. Hence, this investigation will focus on the movement of the isolated shooting hand while shooting by subtracting the movement of the knee using the trigonometric R method.

Mathematical Approaches

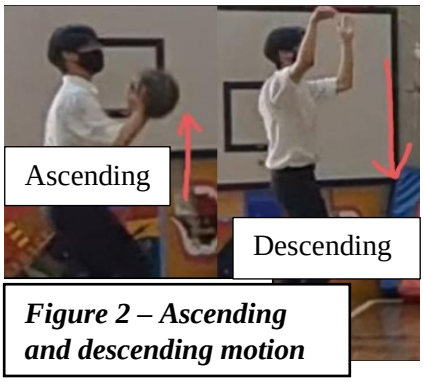


Figure 2 – Ascending and descending motion

As mentioned previously, shooting motion has ascending and descending parts to the movement (figure 2) that looks similar to that of trigonometric functions: sine and cosine. As shown in figure 3, when shooting hand motion is plotted on a graph, it sketches out a similar graph to a sine curve. The knee motion also has a similar shape to the negative cosine graph as shown in figure 4. To display this movement mathematically, the upper body movement will be captured using a tracking application and graphed onto a sine graph while lower body movement will be graphed onto a negative cosine graph. This is because, during shooting, the shooting hand goes up while the knee goes down to bring momentum up for jump: shooting hand and knee move the opposite way.

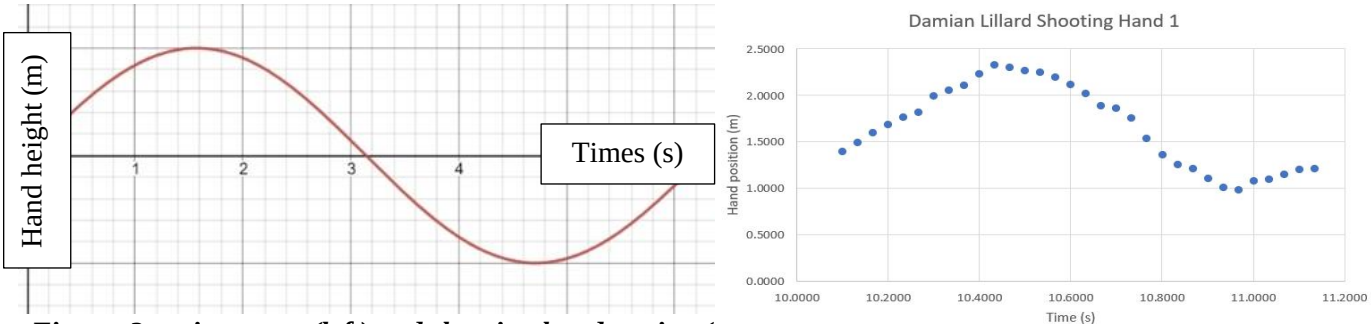


Figure 3 – sine curve (left) and shooting hand motion (right)

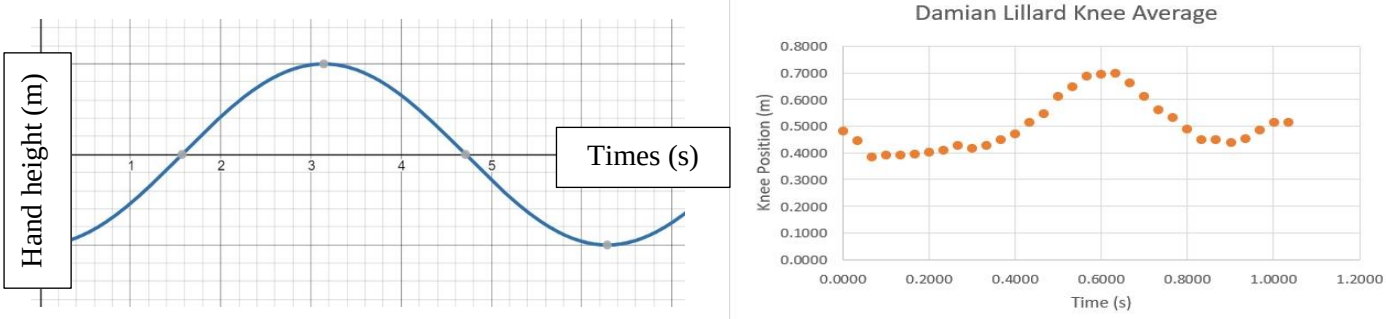


Figure 4 – Negative cosine curve (left) and knee motion (right)

For this investigation, I will be tracking five different shooting motions to collect data points to compare my movement to the ideal. Using those data points, I will calculate the average value for shooting hand and knee motion. After graphing the data points for hand and knee, I will derive its trigonometric function using the *t*- and *y*-values of the maximum and minimum points.

$$y = a\sin(bt) + d$$

$$a = \frac{\text{maximum } y \text{ value} - \text{minimum } y \text{ value}}{2}, d = \frac{\text{maximum } y \text{ value} + \text{minimum } y \text{ value}}{2}, b = \frac{2\pi}{\text{period}}$$

However, as mentioned previously, shooting motion is a simultaneous movement of both the upper and lower body, and this investigation aims to study the detailed movement of the isolated hand movement. To mathematically represent this, I will subtract the functions for modeling the knee motion from that of the shooting hand motion. I will then use the trigonometric R method to combine separate sines and cosines into a single sine or cosine function (Katz, n.d.).

$$a\sin\theta + b\cos\theta = R\sin(\theta + \alpha)$$

When the function on the right-hand side (RHS) is expanded, it becomes the function below.

$$R\sin(\theta + \alpha) = R(\sin\theta\cos\alpha + \sin\alpha\cos\theta) = R\sin\theta\cos\alpha + R\sin\alpha\cos\theta$$

Comparing the coefficients of sinθ and cosθ to the function $a\sin\theta + b\cos\theta$, the coefficients *a* and *b* are $R\cos\alpha$ and $R\sin\alpha$ respectively.

$$①\ R\cos\alpha = a$$

$$②\ R\sin\alpha = b$$

Using these coefficients, I will calculate the value for R and α values using the functions below.

$$\sqrt{①^2 + ②^2} = \sqrt{(R\cos\alpha)^2 + (R\sin\alpha)^2} = \sqrt{R^2(\sin^2\alpha + \cos^2\alpha)} = \sqrt{R^2} = R$$

$$\therefore R = \sqrt{a^2 + b^2}$$

and

$$\frac{②}{①} = \frac{R\sin\alpha}{R\cos\alpha} = \tan\alpha;$$

$$\therefore \tan(\alpha) = \frac{b}{a}$$

Methodology

1. Collect the data for hand and knee motion using 'Tracker.' Collect data for a total of ten jump shots (five each for Damian Lillard and me).
2. Calculate the average of the data sets.
3. Model hand and knee motion using the sine and negative cosine curve.
4. Derive the isolated hand motion using the trigonometric R method.
5. Compare my isolated hand and knee motion to that of Damian Lillard's using RMSE to identify the potential problems with my shooting motion.

Data Collection

For the upper and lower body movement, I will use the 'Tracker' application to plot data points for the shooting hand and right knee. To do this, I will be tracking hand and knee movement using video of the ideal and myself. Figure 5 shows the vertical movement of the shooting hand and knee being tracked. I then plotted the data below, where the *y*-axis is the height of the shooting hand and knee, and the *x*-axis is the time taken to complete a single shooting motion (Appendix 1&2). These data points will be graphed into five different graphs to show the vertical movement of the upper and lower body while shooting (figure 6). For conciseness, all the calculations will only involve shooting hand motions, but the same calculation is also applied to the knee as well. I will then average out all five graphs into a single graph.

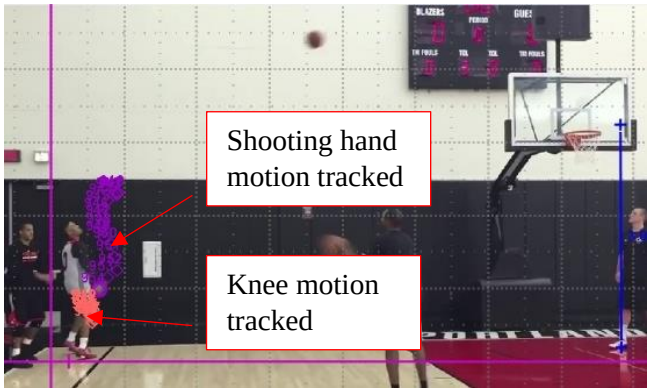


Figure 5 – Video of Damian Lillard on Tracker

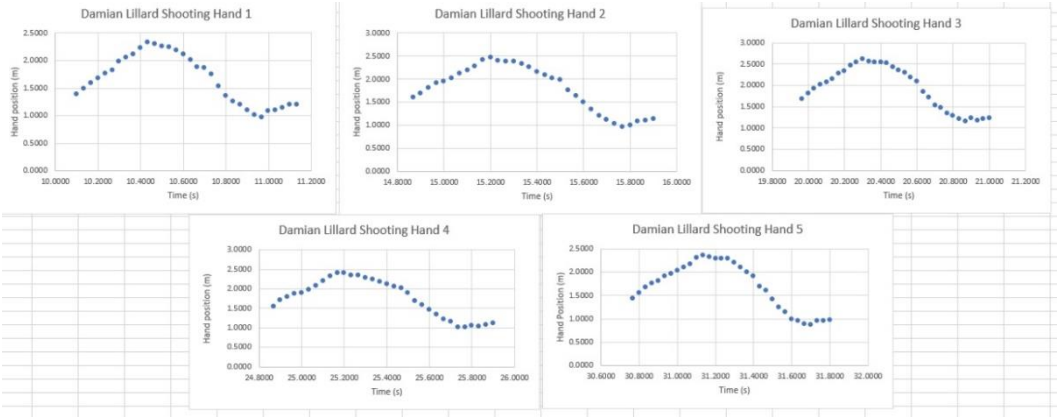


Figure 6 – Damian Lillard shooting hand movement

Also, to compare my shooting percentage to that of Damian Lillard's, I have decided to record the number of shots Damian Lillard made in his practice video. In the video, he attempted a total of 16 jump shots and made 11 of them. To compare my shooting percentage to his, I have also attempted 16 jump shots. The result is displayed in appendix 15.

Calculations

1. Calculation for Average Height for Hand and Knee

To find the graph most representative of the usual motion, *y*-values from each graph will be added and divided by five to calculate the average value for each data point.

Calculation 1	Example
Average formula: $$\bar{y} = \frac{\sum y}{N}$$ $\bar{y}$ **= average height of the hand** Σy **= Sum of all height of the hand** N **= Number of data points**	***data points from appendix 3 are used*** $$\Sigma y = (1.395 + 1.599 + 1.684 + 1.540 + 1.432) \approx 7.65$$ $$N = 5$$ $$\bar{y} = \frac{\mathbf{7.65}}{\mathbf{5}} \approx \mathbf{1.53}$$

Table 1 – Sample calculations for mean values

This process is repeated for every data point for both hands and knee movement (appendix 5&6). When the average data points for both hand and knee are plotted on the graph, it will show a graph similar to the sine graph and negative cosine graph as shown in figure 7.

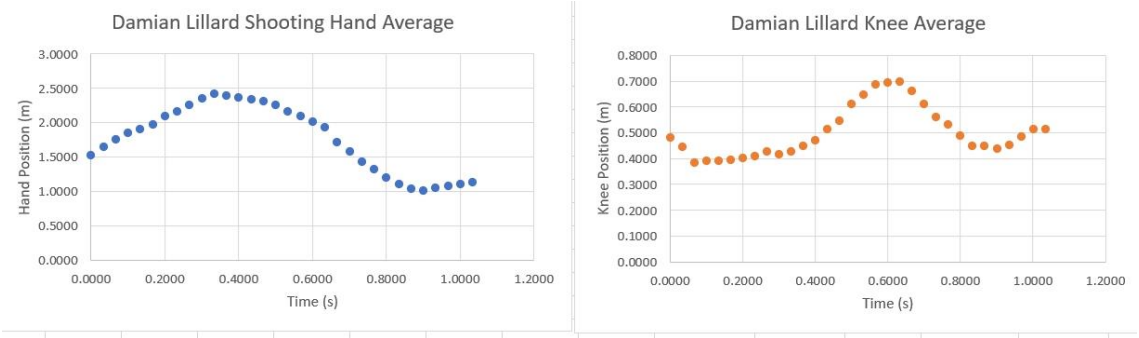


Figure 7 –Damian Lillard shooting hand (left) and knee (right) average movement

2. Modelling The Hand Motion Using Sine Curve

By using the maximum and minimum points from appendixes 5 and 6, I will calculate trigonometric functions for shooting hand and knee. According to appendix 5, the coordinate for the maximum is (0.333, 2.425) and the coordinate for the

minimum is (0.9, 1.020). I will be using these coordinates to estimate the trigonometric function for shooting the hand in terms of sine (calculation 2).

Calculation 2	Example
Trigonometric function formula: $$\boldsymbol{a\sin(bt)+d}$$	***data points from appendix 5 are used*** Maximum = (0.333, 2.425) Minimum = (0.9, 1.020)
$$\boldsymbol{a=\frac{max-min}{2}}$$	$$a=\frac{(2.425-1.020)}{2}\approx 0.703$$
$$\boldsymbol{d=\frac{max+min}{2}}$$	$$d=\frac{(2.4250+1.0201)}{2}\, d\approx 1.723$$ $$\text{period}\approx(0.9-0.333)*2$$
$$\boldsymbol{\frac{2\pi}{b}=period}$$	$$b=\frac{2\pi}{1.134}\approx 5.541$$ $$\boldsymbol{y_1=0.703\sin(5.541t)+1.723}$$

Table 2 – Sample calculation for deriving trigonometric functions

To calculate trigonometric function for knee movement, I will use the same method for calculation 2. For knee movement, the coordinate for maximum is (0.633, 0.701), and the coordinate for the minimum is (0.067, 0.385).

$$y_2=-0.158\cos(5.551t)+0.543$$

3. Modelling The Isolated Hand Motion Using The R Method

To subtract these two separate functions to create a mathematical expression for isolated movement for the shooting hand, I used the trigonometric R method.

$$a\sin\theta+b\cos\theta=R\sin(\theta+\alpha)$$

However, for this equation to work, the θ value should be the same. Currently, both formulae have different θ values of $5.541t$ and $5.551t$. Hence, to combine these two functions, θ will be assumed to be $5.5t$.

Calculation 3	Example
R Method Formula: $\boldsymbol{a\sin\theta + b\cos\theta = R\sin(\theta + \alpha)}$	$y_1 = 0.703\sin(5.5x) + 1.723;\ y_2 = -0.158\cos(5.5x) + 0.543$ $y_1 - y_2 = 0.703\sin(5.5x) + 1.723 - (-0.158\cos(5.5x) + 0.543)$ $\approx 0.703\sin(5.5x) + 0.158\cos(5.5x) + 1.180$
$\boldsymbol{R = \sqrt{a^2 + b^2}}$	$y_3 = R\sin(5.5x + \alpha) + 1.18$ $R = \sqrt{(0.703)^2 + (0.158)^2} \approx 0.721$
$\boldsymbol{\tan(\alpha) = \frac{b}{a}}$	$\tan(\alpha) = \frac{0.158}{0.703}$ $\alpha = \tan^{-1}\left(\frac{0.158}{0.703}\right) \approx 0.221$ $\boldsymbol{y_3 = 0.721\sin(5.5t + 0.221) + 1.18}$

Table 3 – Sample calculation for R method

Hence, the isolated hand motion is expressed mathematically as $y = 0.721\sin(5.5t - 0.221) + 1.18$.

For my hand and knee movement, I will apply the same calculation method from calculations 1, 2, and 3.

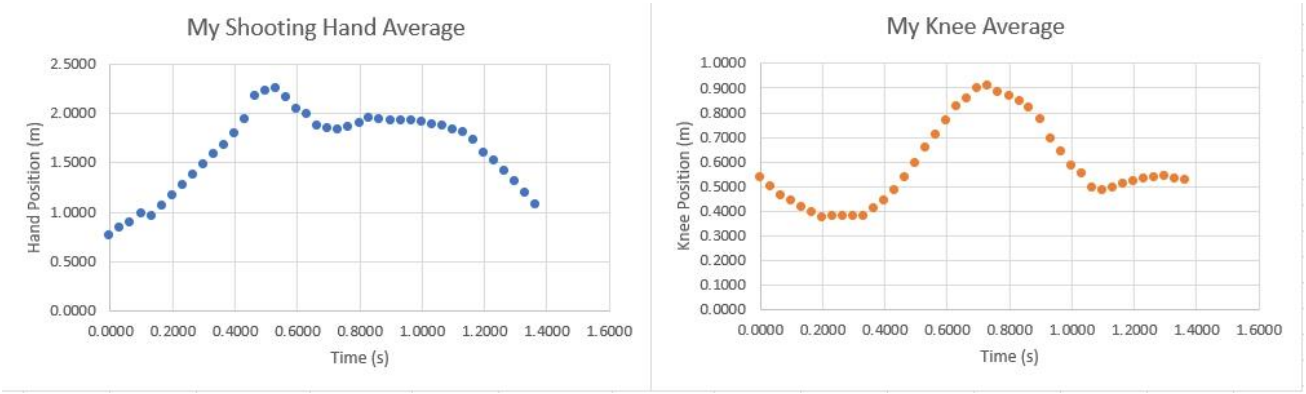


Figure 8 – My shooting hand (left) and knee (right) average movement (appendix 11&12)

To calculate trigonometric functions for my hand using maximum and minimum: shooting hand maximum (0.533, 2.252), shooting hand minimum (0, 0.763) (appendix 11).

$$\boldsymbol{y_1 \approx 0.745\sin(5.89t) + 1.51}$$

Knee maximum coordinate (0.733, 0.905), and knee minimum coordinate (0.2, 0.374) (appendix 12).

$$\boldsymbol{y_2 \approx -0.266\cos(5.89t) + 0.640}$$

Fortunately, for these functions, the θ value (5.894) is the same when it is rounded up to the nearest thousand. Hence, there is no need to round it.

$$\boldsymbol{y_3 = 0.791\sin(5.89t + 0.343) + 0.868}$$

To compare my isolated hand motion to that of Damian Lillard's, I graphed trigonometric functions for my isolated shooting hand ($y = 0.791\sin(5.89t + 0.343) + 0.868$) and Damian Lillard's ($y = 0.721\sin(5.5t - 0.221) + 1.18$) on the same plot using software called Desmos (figure 9).

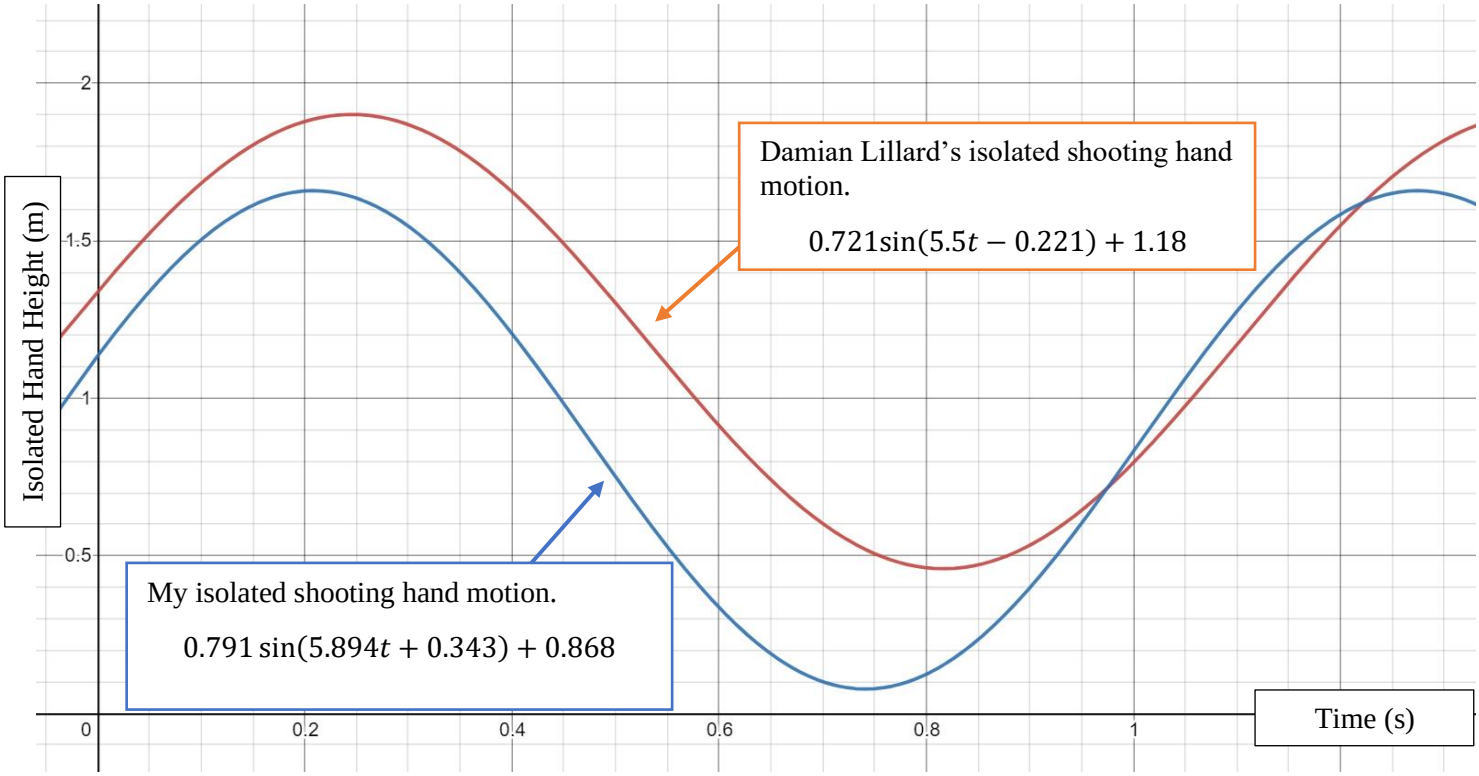


Figure 9 – Comparison of my isolated hand motion and Damian Lillard's isolated shooting motion

Analysis

Only the first cycle of the graph is shown because this is the part that corresponds to a single shooting motion. As shown in figure 9, there is a gap between the two graphs. The discrepancy between the two functions is the difference in the height of the shooting hand. The height difference of the isolated hand movement shows that Damian Lillard is releasing the ball at a higher point than me. It shows that Damian Lillard is shooting higher than me which makes it more difficult for defenders to block the shot. Hence, my shooting motion is lower than Damian Lillard's shot which might be the reason why my shooting percentage (25%) is very low. Although the difference between the two graphs may appear to be small, shooting

a basketball is a very delicate process, and even a small error in shooting leads to missing the shot. Since the rim has a very small size, it is very difficult and requires a lot of skills to shoot the ball accurately. Hence, the small difference between the two trigonometric functions shows that my jump shot is different from that of a professional player, and there may be problems with my shooting mechanism which results in a poor shot percentage of 25% as shown in appendix 15.

To investigate whether my shooting hand motion or my knee movement is the problem, my upper body and lower body movement will each be compared to the professional player's. To do this, I will use root means square error (RMSE). RMSE is a way to measure the difference between the predicted values and observed values. If the RMSE value is lower, it indicates that the observed data fit the ideal data well (Moody, 2019). In other words, the smaller the RMSE, the more similar the two data sets are. Any motion with a relatively higher RMSE value may be the motion that is resulting in my poor shooting percentage.

Calculation 4	Example
$\mathbf{RMSE} = \sqrt{\frac{\sum(\boldsymbol{y}_{\mathbf{ideal}} - \boldsymbol{y}_{\mathbf{observed}})^2}{\boldsymbol{n}}}$ $\boldsymbol{y}_{\mathbf{ideal}}$ $= \mathbf{isolated\ hand\ height\ \ for\ Damian\ Lillard}$ $\boldsymbol{y}_{\mathbf{observed}} =$ isolated hand height for me $\boldsymbol{n} =$ total number of data points	***data points from appendixes 5 and 11 are used*** $n = 32$ $\sum(y_{\text{ideal}} - y_{\text{observed}})^2 \approx 15.52 \ldots$ $\mathbf{RMSE} = \sqrt{\frac{\mathbf{15.52}}{\mathbf{32}}} \approx \sqrt{\mathbf{0.485}} \approx \mathbf{0.696}$

Table 4 – Sample calculation for RMSE value

Hence, the RMSE value for my shooting hand is 0.696 when compared to the professionals.

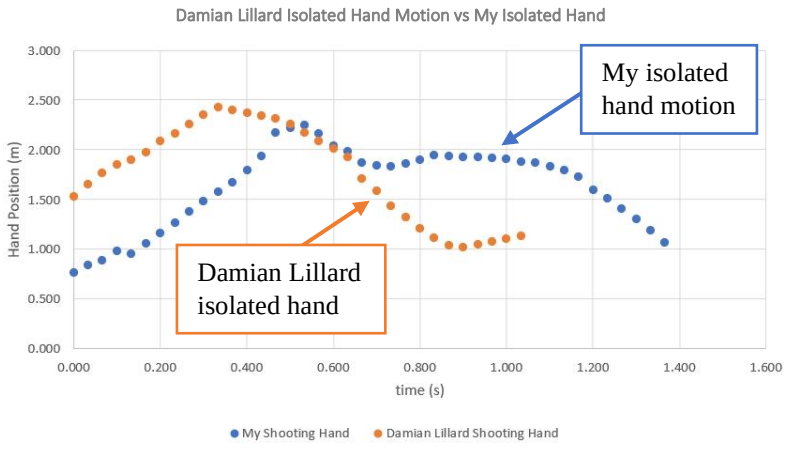


Figure 10 – Damian Lillard (orange) and my (blue) isolated shooting hand movement compared

As shown in figure 10, it can be seen that Damian Lillard's shooting is much quicker than mine. It takes less time for him to reach the peak (where the ball is released) compared to mine which is approximately 0.2 seconds slower. Also after releasing the ball, his hand starts to decline immediately while my hand stays up in the air longer. Therefore, it can be said that Damian Lillard's shooting hand has quicker and more efficient movement compared to mine.

Likewise, I compared my knee movement to that of Damian Lillard using the same method from calculation 4.

$$\text{RMSE} = \sqrt{0.0320} \approx 0.179$$

For the knee movement, the RMSE value is 0.179 which is very low compared to that of hand movement. It means that there is a relatively small difference. This is also shown when both knee movements are graphed together.

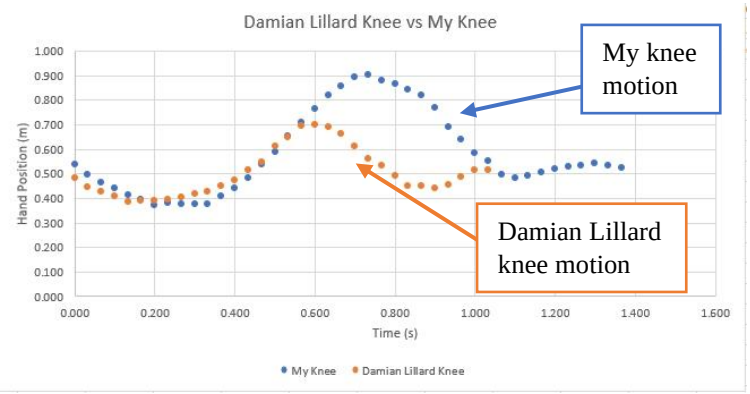


Figure 11 – Damian Lillard (orange) and my (blue) knee movement compared

As shown in figure 11, it can be seen that my knee movement is almost identical to Damian Lillard's for the first 0.5 seconds. However, similar to the hand movement, Damian Lillard's knee reaches the peak much quicker than mine. It can be seen that my lower body is elevating much higher when shooting. In contrast, Damian Lillard does not jump high which makes his overall shooting motion quicker. Hence, although my knee movement resembles that of Damian Lillard, it is much slower and more exaggerated.

Comparing my RMSE values for my hand (0.696) and knee (0.179), it appears that my hand motion has a relatively higher RMSE value than that of my knee motion. As previously mentioned, if the RMSE value is higher, it indicates that there is a relatively bigger discrepancy between the observed data and the predicted data (Moody, 2019). While Damian Lillard made 68.8% of 3-point shots using his shooting motion, I only made 25.0% of my 3-points using my shooting motion which is a very poor percentage for a basketball player (appendix 15). Hence, since my shooting hand movement has a higher

RMSE value than the value of the knee movement, this suggests that my shooting hand moves differently compared to Damian Lillard's hand movement when releasing the ball.

To improve my shooting percentage, I will need to change my shooting mechanism so it has a more similar motion to Damian Lillard's hand movement. Based on all the calculations and analysis, there are a few areas that can be improved to enhance my shooting. However, I would not use the trigonometric functions for Damian Lillard and my shooting motion (figure 9) since it is not the best representation of the movement. Instead, I will be using the data for my actual shooting hand movement to make a graph.

Point 1: Shooting motion should be less exaggerated

As shown in figure 12, my shooting motion was often exaggerated. For example, after releasing the ball, my shooting hand stayed in the air for too long compared to Damian Lillard. This type of exaggeration might lead to unnecessary movements that can hinder me from delivering my momentum to the basketball. For a quicker and more accurate shooting motion, my shooting hand should come down after releasing the ball at the peak, and my jump should be slightly lower to prevent unnecessary energy use.

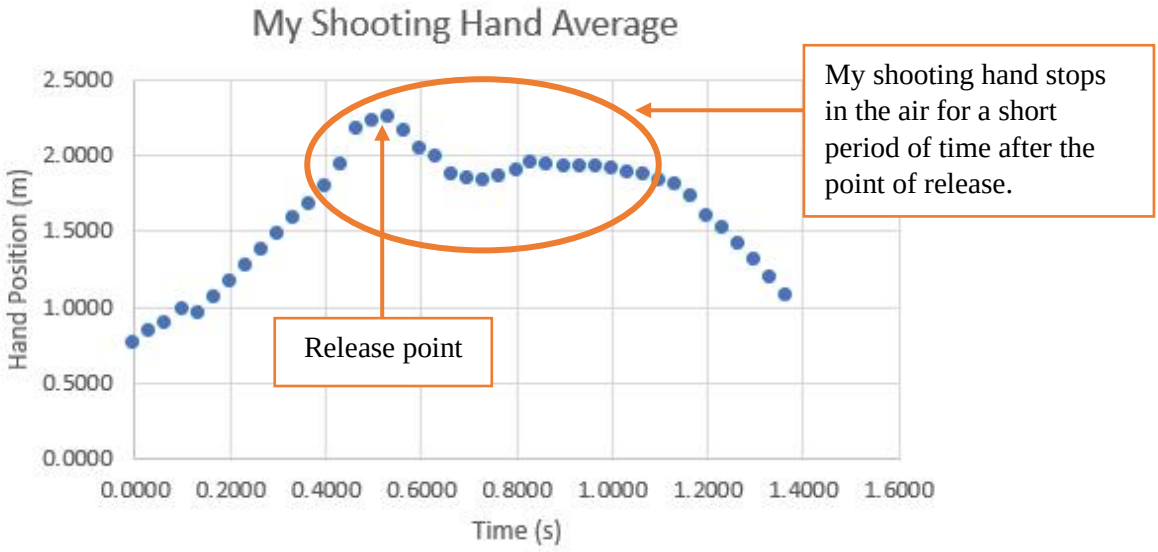


Figure 12 – My shooting hand motion

Point 2: The release should be quicker

As mentioned in the analysis section, my shooting hand reached the peak around 0.2 seconds later than Damian Lillard (figure 13). Although 0.2 seconds might seem there is not much difference, it is crucial to release the ball as quickly as possible since, during a basketball game, defenders who are guarding my shot are usually taller. To avoid their hands from

blocking my shot, I have to release the ball as quickly as possible. However, just releasing quickly will not improve my shooting. Typically, quicker release leads to less accuracy since there is not much time to adjust the hand to shoot the ball straight. Hence, I need to practice more practice to release the ball quickly but also enhance shooting accuracy.

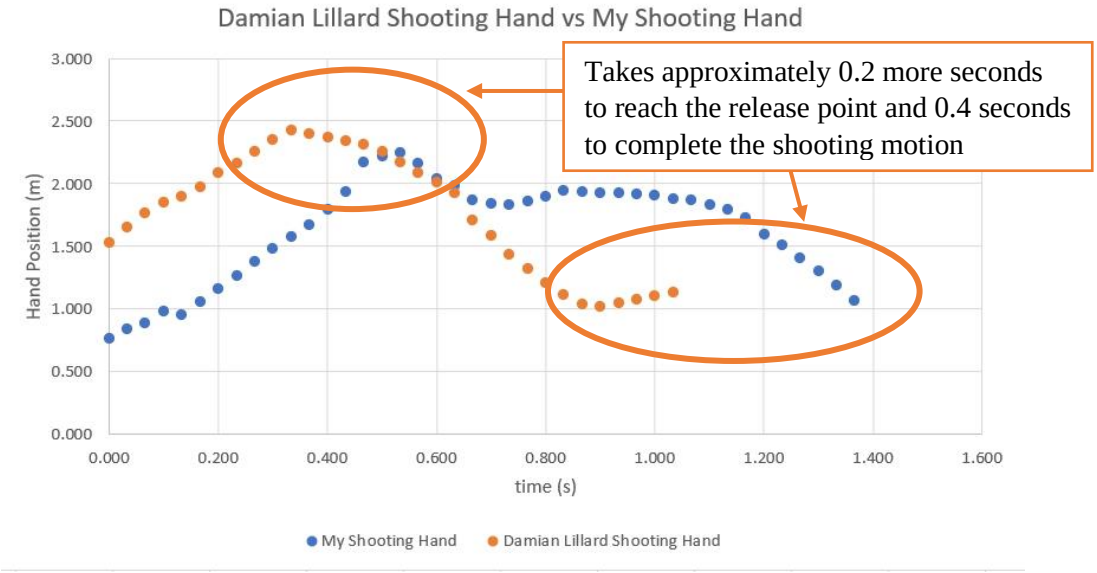


Figure 13 – Comparing time taken for shooting

Point 3: Overall shooting motion should be smoother and consistent

As mentioned in point 1, some unnecessary movements are interrupting my shooting. On the graph, these movements result in a less smooth curve. For example in figure 13, Damian Lillard's shooting motion is very smooth and it almost resembles a perfect sine curve. The differences between each data point are consistent throughout the curve with the difference of only approximately 0.1. However, my shooting curve does not look similar to a normal sine curve. Also, differences between each data point are relatively inconsistent as there are few extreme leaps and drops. For instance, from 0.433 seconds to 0.466 seconds, my hand rises from 1.936 m to 2.172 m which is a difference of 0.236 (figure 14). To make my shooting motion more consistent, it is important to keep in mind that my vertical movement should be fully in control while shooting.

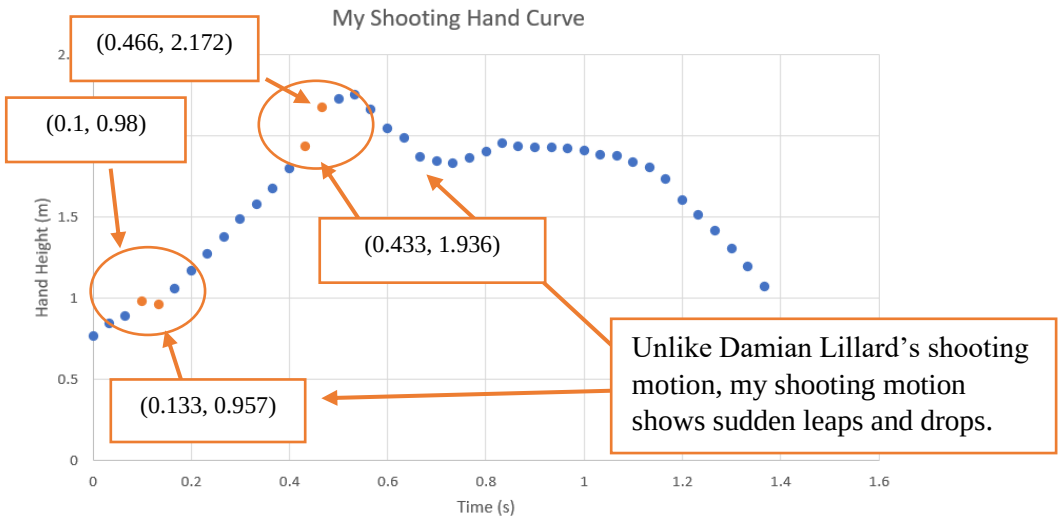


Figure 14 – Inconsistency in my shooting hand

Conclusion

Although my shooting motion showed some similarities to that of Damian Lillard, I still need to improve my shooting motion for a higher shooting percentage. To improve my shooting, the release time should be shortened and the overall body movement should be less exaggerated to make my shooting motion smoother and more energy-efficient while shooting with high accuracy. More specifically, my shooting hand should have less exaggerated motion to make my hand movement similar to that of Damian Lillard. It should have a quick movement while also maintaining a consistent and accurate motion. However, other parts of the body contribute to shooting such as the guiding hand (left hand), hip, and elbow. Hence, it is difficult to simply say my shooting hand is the only factor that is influencing my shooting percentage as the limitation is huge. Instead, it can be concluded that my shooting hand is one of the many factors that are influencing my shooting motion and it is crucial to improve my shooting hand movement to enhance my shooting percentage.

Evaluation

Limitations	Impacts	Improvement
Low Resolution	Because of the low quality of the video, Damian Lillard and my hand movements were often blurry. Therefore, it was difficult to track the exact point where the hand is positioned. Therefore, the hand position data were less accurate.	For improvement, Damian Lillard's jump shot video quality should be better. Hence, more internet research is required to find the video with enhanced quality. For my jump shot video, using a camera with high resolution will enhance the video quality.
Tracker	Since the auto-tracking option had an error, all the tracking was done manually. The data points were tracked using my hand and mouse. Hence, there will be some errors due to human errors such as shaking hands and visual judgment.	To reduce the error, the video should be in a higher resolution so the tracker can auto-track upper and lower body movement and plot the data point.
Camera Shaking	When both videos were filmed, the camera was held by a person. Since human hands cannot hold the camera still, the camera started to move slowly. Therefore, it made the tracking process more difficult and less accurate.	For improvement, the camera should be on the camera stand since the camera stand stays still unlike human hands. Then, the camera would be held steadily and record video with less shaking.
Estimating θ value for R method	Because the two θ values for Damian Lillard were different, θ values were rounded up to the tenth place and assumed that they are both 5.5. Because the exact value wasn't used, the actual move would be slightly different compared to the derived function.	For improvement, the number of trials should be increased to minimize the difference between two θ values. If more data points are available, the average value would be closer to each other.

Limitations	Impacts	Improvement
Number of data points used in RMSE calculation	As shown in figures 9 and 10, there are more data points present for my hand and knee movement than that of Damian Lillard. When calculating the RMSE value, the observed and ideal values are subtracted. Since Damian Lillard had fewer data points, I had to neglect other data points after Damian Lillard's last point since I could not subtract data from non-existing ones. Hence, the RMSE value will be slightly different which will result in lower accuracy.	To make the number of data points for both my and Damian Lillard's data equal, I have to reduce the time for my shooting motion. As it appears in figure 12, my shooting motion takes approximately 0.4 seconds more. Hence, after practicing and improving my jump shot for a while and reducing my shooting time, the RMSE value will have less error when it is calculated again later.

The most significant limitation is the "number of data points used in RMSE calculation." This is because I am assuming both Damian Lillard and my data sets for hand and knee motion have the same number of values although my data have much more data points. Since I decided not to include the last ten data points in the RMSE calculation, my RMSE value for both shooting hand and knee motion will be inaccurate. It is difficult to know how different the latter part of my shooting motion is from that of Damian Lillard's. Also, unlike other limitations which I can improve by using different measuring equipment or increasing the number of trials, the only way to make the number of data the same is by practicing and releasing the ball more quickly. However, I would never be able to imitate Damian Lillard's shooting motion because of the physical difference. Considering Damian Lillard is 191cm (6'3ft) tall and his wingspan is nearly 2m (6'7.75ft) (*NBA Advanced* Stats, n.d.) while both my height and wingspan is only 177cm, I would not be able to overcome physical difference and improve my shooting motion just by practicing.

Further Investigation

For further investigation, I would like to continue working on my jump shots using RMSE analysis to reduce the discrepancy. By using trigonometry graph and RMSE calculation, I would compare my jump shot to that of professional players to see how my jump shot is improving. For more comparison, my shooting motion can be compared not only to Damian Lillard's but also to other players such as Stephen Curry and Ray Allen who are known for high shooting accuracy. In addition to this, to expand my knowledge about basketball and its mathematical relationship, horizontal movement of upper and lower body movement can also be studied as an extension. For this investigation, only the vertical movement of the body was used to compare my shooting to that of a professional player. However, in real life, the shooting hand does not only move vertically but also horizontally. Moreover, the movement of other parts of the body is also very important. By comparing the horizontal movement of shooting hands and comparing other body parts' movements to that of professional athletes, it would be possible to know more detailed issues with my shooting motion.

Bibliography

Damian Lillard. (2021). Retrieved July 12th, 2021, from https://www.nba.com/stats/player/203081/?Season=2020-21&SeasonType=Regular%20Season

Katz, A. (n.d.). *Trigonometric R method*. Retrieved July 21st, 2021, from https://brilliant.org/wiki/trigonometric-r-method/

Moody, J. (2019, September 6). *What does RMSE really mean?*. Retrieved July 15th, 2021, from https://towardsdatascience.com/what-does-rmse-really-mean-806b65f2e48e

NBA Advanced Stats. (n.d.). Retrieved December 3rd, 2021, from https://www.nba.com/stats/draft/combine-anthro/?SeasonYear=2012-13

NBA League Averages - Per Game. (2021). Retrieved July 12th, 2021, from https://www.basketball-reference.com/leagues/NBA_stats_per_game.html

Penny, R. (n.d.). *The Overlooked Importance Of Arm & Wrist Angles*. Retrieved July 15th, 2021, from https://www.breakthroughbasketball.com/fundamentals/shooting-arm-wrist-angle.html?filterreviews=oldest

The Stance. (n.d.). Retrieved July 15th, 2021, from https://shotscience.com/pages/premium-preview-shooting

Appendix

Appendix 1: Damian Lillard shooting hand before shifting

Hand 1		Hand 2		Hand 3		Hand 4		Hand 5	
Time (s)	Height (m)	Time (s)	Height (m)	Time (s)	Height (m)	Time (s)	Height (m)	Time (s)	Height (m)
Hand_1	Hand_1	Hand_2	Hand_2	Hand_3	Hand_3	Hand_4	Hand_4	Hand_5	Hand_5
t	y	t	y	t	y	t	y	t	y
10.100	1.395	14.867	1.599	19.967	1.684	24.867	1.540	30.767	1.432
10.133	1.488	14.900	1.692	20.000	1.803	24.900	1.716	30.800	1.559
10.167	1.599	14.933	1.820	20.033	1.931	24.933	1.785	30.833	1.677
10.200	1.684	14.967	1.914	20.067	2.016	24.967	1.873	30.867	1.755
10.233	1.769	15.000	1.956	20.100	2.075	25.000	1.903	30.900	1.804
10.267	1.820	15.033	2.024	20.133	2.152	25.033	1.971	30.933	1.912
10.300	1.990	15.067	2.126	20.167	2.279	25.067	2.089	30.967	1.971
10.333	2.058	15.100	2.186	20.200	2.339	25.100	2.207	31.000	2.030
10.367	2.109	15.133	2.279	20.233	2.475	25.133	2.324	31.033	2.108
10.400	2.228	15.167	2.424	20.267	2.534	25.167	2.403	31.067	2.177
10.433	2.330	15.200	2.466	20.300	2.611	25.200	2.412	31.100	2.305
10.467	2.305	15.233	2.407	20.333	2.568	25.233	2.354	31.133	2.354
10.500	2.262	15.267	2.381	20.367	2.534	25.267	2.344	31.167	2.324
10.533	2.245	15.300	2.381	20.400	2.534	25.300	2.285	31.200	2.285
10.567	2.194	15.333	2.330	20.433	2.517	25.333	2.246	31.233	2.295
10.600	2.118	15.367	2.262	20.467	2.432	25.367	2.187	31.267	2.285
10.633	2.016	15.400	2.160	20.500	2.347	25.400	2.118	31.300	2.207
10.667	1.888	15.433	2.092	20.533	2.305	25.433	2.069	31.333	2.099
10.700	1.863	15.467	2.016	20.567	2.194	25.467	2.010	31.367	2.001
10.733	1.752	15.500	1.990	20.600	2.092	25.500	1.903	31.400	1.912
10.767	1.539	15.533	1.769	20.633	1.854	25.533	1.697	31.433	1.697
10.800	1.361	15.567	1.633	20.667	1.718	25.567	1.599	31.467	1.608
10.833	1.259	15.600	1.497	20.700	1.531	25.600	1.461	31.500	1.422
10.867	1.208	15.633	1.352	20.733	1.480	25.633	1.334	31.533	1.245
10.900	1.106	15.667	1.208	20.767	1.344	25.667	1.226	31.567	1.147
10.933	1.012	15.700	1.123	20.800	1.284	25.700	1.157	31.600	0.990
10.967	0.978	15.733	1.038	20.833	1.216	25.733	1.020	31.633	0.951
11.000	1.080	15.767	0.970	20.867	1.148	25.767	1.010	31.667	0.892
11.033	1.097	15.800	0.995	20.900	1.233	25.800	1.049	31.700	0.873
11.067	1.148	15.833	1.080	20.933	1.174	25.833	1.040	31.733	0.951
11.100	1.199	15.867	1.106	20.967	1.208	25.867	1.069	31.767	0.961
11.133	1.208	15.900	1.140	21.000	1.233	25.900	1.108	31.800	0.981

Appendix 2: Damian Lillard knee before shifting

Knee 1		Knee 2		Knee 3		Knee 4		Knee 5	
Time (s)	Height (m)	Time (s)	Height (m)	Time (s)	Height (m)	Time (s)	Height (m)	Time (s)	Height (m)
Knee_1	Knee_1	Knee_2	Knee_2	Knee_3	Knee_3	Knee_4	Knee_4	Knee_5	Knee_5
t	y	t	y	t	y	t	y	t	y
10.100	0.226	14.867	0.432	19.967	0.520	24.867	0.637	30.767	0.598
10.133	0.167	14.900	0.383	20.000	0.500	24.900	0.618	30.800	0.559
10.167	0.157	14.933	0.373	20.033	0.461	24.933	0.607	30.833	0.539
10.200	0.147	14.967	0.363	20.067	0.451	24.967	0.569	30.867	0.520
10.233	0.128	15.000	0.324	20.100	0.441	25.000	0.549	30.900	0.481
10.267	0.118	15.033	0.324	20.133	0.461	25.033	0.569	30.933	0.490
10.300	0.108	15.067	0.324	20.167	0.461	25.067	0.569	30.967	0.500
10.333	0.108	15.100	0.314	20.200	0.471	25.100	0.584	31.000	0.500
10.367	0.088	15.133	0.314	20.233	0.475	25.133	0.598	31.033	0.539
10.400	0.078	15.167	0.324	20.267	0.481	25.167	0.608	31.067	0.588
10.433	0.078	15.200	0.343	20.300	0.490	25.200	0.647	31.100	0.588
10.467	0.127	15.233	0.373	20.333	0.491	25.233	0.648	31.133	0.609
10.500	0.167	15.267	0.412	20.367	0.500	25.267	0.657	31.167	0.628
10.533	0.206	15.300	0.441	20.400	0.539	25.300	0.696	31.200	0.686
10.567	0.235	15.333	0.490	20.433	0.588	25.333	0.716	31.233	0.716
10.600	0.304	15.367	0.559	20.467	0.647	25.367	0.775	31.267	0.775
10.633	0.353	15.400	0.579	20.500	0.696	25.400	0.814	31.300	0.795
10.667	0.412	15.433	0.598	20.533	0.785	25.433	0.873	31.333	0.814
10.700	0.461	15.467	0.598	20.567	0.795	25.467	0.883	31.367	0.765
10.733	0.432	15.500	0.579	20.600	0.785	25.500	0.912	31.400	0.736
10.767	0.422	15.533	0.520	20.633	0.745	25.533	0.892	31.433	0.736
10.800	0.373	15.567	0.500	20.667	0.745	25.567	0.775	31.467	0.677
10.833	0.353	15.600	0.461	20.700	0.637	25.600	0.706	31.500	0.656
10.867	0.343	15.633	0.441	20.733	0.627	25.633	0.618	31.533	0.637
10.900	0.245	15.667	0.422	20.767	0.608	25.667	0.617	31.567	0.559
10.933	0.216	15.700	0.363	20.800	0.520	25.700	0.608	31.600	0.549
10.967	0.226	15.733	0.373	20.833	0.510	25.733	0.608	31.633	0.538
11.000	0.235	15.767	0.382	20.867	0.451	25.767	0.588	31.667	0.539
11.033	0.255	15.800	0.393	20.900	0.500	25.800	0.579	31.700	0.539
11.067	0.284	15.833	0.414	20.933	0.500	25.833	0.618	31.733	0.618
11.100	0.314	15.867	0.434	20.967	0.510	25.867	0.677	31.767	0.637
11.133	0.275	15.900	0.442	21.000	0.528	25.900	0.686	31.800	0.637

Appendix 3: Damian Lillard shooting hand after shifting

Hand 1		**Hand 2**		**Hand 3**		**Hand 4**		**Hand 5**	
Time (s)	Height (m)	Time (s)	Height (m)	Time (s)	Height (m)	Time (s)	Height (m)	Time (s)	Height (m)
Hand_1	Hand_1	Hand_2	Hand_2	Hand_3	Hand_3	Hand_4	Hand_4	Hand_5	Hand_5
t	y	t	y	t	y	t	y	t	y
0.000	1.395	0.000	1.599	0.000	1.684	0.000	1.540	0.000	1.432
0.033	1.488	0.033	1.692	0.033	1.803	0.033	1.716	0.033	1.559
0.067	1.599	0.067	1.820	0.067	1.931	0.067	1.785	0.067	1.677
0.100	1.684	0.100	1.914	0.100	2.016	0.100	1.873	0.100	1.755
0.133	1.769	0.133	1.956	0.133	2.075	0.133	1.903	0.133	1.804
0.167	1.820	0.167	2.024	0.167	2.152	0.167	1.971	0.167	1.912
0.200	1.990	0.200	2.126	0.200	2.279	0.200	2.089	0.200	1.971
0.233	2.058	0.233	2.186	0.233	2.339	0.233	2.207	0.233	2.030
0.267	2.109	0.267	2.279	0.267	2.475	0.267	2.324	0.267	2.108
0.300	2.228	0.300	2.424	0.300	2.534	0.300	2.403	0.300	2.177
0.333	2.330	0.333	2.466	0.333	2.611	0.333	2.412	0.333	2.305
0.367	2.305	0.367	2.407	0.367	2.568	0.367	2.354	0.367	2.354
0.400	2.262	0.400	2.381	0.400	2.534	0.400	2.344	0.400	2.324
0.433	2.245	0.433	2.381	0.433	2.534	0.433	2.285	0.433	2.285
0.467	2.194	0.467	2.330	0.467	2.517	0.467	2.246	0.467	2.295
0.500	2.118	0.500	2.262	0.500	2.432	0.500	2.187	0.500	2.285
0.533	2.016	0.533	2.160	0.533	2.347	0.533	2.118	0.533	2.207
0.567	1.888	0.567	2.092	0.567	2.305	0.567	2.069	0.567	2.099
0.600	1.863	0.600	2.016	0.600	2.194	0.600	2.010	0.600	2.001
0.633	1.752	0.633	1.990	0.633	2.092	0.633	1.903	0.633	1.912
0.667	1.539	0.667	1.769	0.667	1.854	0.667	1.697	0.667	1.697
0.700	1.361	0.700	1.633	0.700	1.718	0.700	1.599	0.700	1.608
0.733	1.259	0.733	1.497	0.733	1.531	0.733	1.461	0.733	1.422
0.767	1.208	0.767	1.352	0.767	1.480	0.767	1.334	0.767	1.245
0.800	1.106	0.800	1.208	0.800	1.344	0.800	1.226	0.800	1.147
0.833	1.012	0.833	1.123	0.833	1.284	0.833	1.157	0.833	0.990
0.867	0.978	0.867	1.038	0.867	1.216	0.867	1.020	0.867	0.951
0.900	1.080	0.900	0.970	0.900	1.148	0.900	1.010	0.900	0.892
0.933	1.097	0.933	0.995	0.933	1.233	0.933	1.049	0.933	0.873
0.967	1.148	0.967	1.080	0.967	1.174	0.967	1.040	0.967	0.951
1.000	1.199	1.000	1.106	1.000	1.208	1.000	1.069	1.000	0.961
1.033	1.208	1.033	1.140	1.033	1.233	1.033	1.108	1.033	0.981

Appendix 4: Damian Lillard knee after shifting

Knee 1		Knee 2		Knee 3		Knee 4		Knee 5	
Time (s)	Height (m)	Time (s)	Height (m)	Time (s)	Height (m)	Time (s)	Height (m)	Time (s)	Height (m)
Knee_1	Knee_1	Knee_2	Knee_2	Knee_3	Knee_3	Knee_4	Knee_4	Knee_5	Knee_5
t	y	t	y	t	y	t	y	t	y
0.000	0.226	0.000	0.432	0.000	0.520	0.000	0.637	0.000	0.598
0.033	0.167	0.033	0.383	0.033	0.500	0.033	0.618	0.033	0.559
0.067	0.157	0.067	0.373	0.067	0.461	0.067	0.607	0.067	0.539
0.100	0.147	0.100	0.363	0.100	0.451	0.100	0.569	0.100	0.520
0.133	0.128	0.133	0.324	0.133	0.441	0.133	0.549	0.133	0.481
0.167	0.118	0.167	0.324	0.167	0.461	0.167	0.569	0.167	0.490
0.200	0.108	0.200	0.324	0.200	0.461	0.200	0.569	0.200	0.500
0.233	0.108	0.233	0.314	0.233	0.471	0.233	0.584	0.233	0.500
0.267	0.088	0.267	0.314	0.267	0.475	0.267	0.598	0.267	0.539
0.300	0.078	0.300	0.324	0.300	0.481	0.300	0.608	0.300	0.588
0.333	0.078	0.333	0.343	0.333	0.490	0.333	0.647	0.333	0.588
0.367	0.127	0.367	0.373	0.367	0.491	0.367	0.648	0.367	0.609
0.400	0.167	0.400	0.412	0.400	0.500	0.400	0.657	0.400	0.628
0.433	0.206	0.433	0.441	0.433	0.539	0.433	0.696	0.433	0.686
0.467	0.235	0.467	0.490	0.467	0.588	0.467	0.716	0.467	0.716
0.500	0.304	0.500	0.559	0.500	0.647	0.500	0.775	0.500	0.775
0.533	0.353	0.533	0.579	0.533	0.696	0.533	0.814	0.533	0.795
0.567	0.412	0.567	0.598	0.567	0.785	0.567	0.873	0.567	0.814
0.600	0.461	0.600	0.598	0.600	0.795	0.600	0.883	0.600	0.765
0.633	0.432	0.633	0.579	0.633	0.785	0.633	0.912	0.633	0.736
0.667	0.422	0.667	0.520	0.667	0.745	0.667	0.892	0.667	0.736
0.700	0.373	0.700	0.500	0.700	0.745	0.700	0.775	0.700	0.677
0.733	0.353	0.733	0.461	0.733	0.637	0.733	0.706	0.733	0.656
0.767	0.343	0.767	0.441	0.767	0.627	0.767	0.618	0.767	0.637
0.800	0.245	0.800	0.422	0.800	0.608	0.800	0.617	0.800	0.559
0.833	0.216	0.833	0.363	0.833	0.520	0.833	0.608	0.833	0.549
0.867	0.226	0.867	0.373	0.867	0.510	0.867	0.608	0.867	0.538
0.900	0.235	0.900	0.382	0.900	0.451	0.900	0.588	0.900	0.539
0.933	0.255	0.933	0.393	0.933	0.500	0.933	0.579	0.933	0.539
0.967	0.284	0.967	0.414	0.967	0.500	0.967	0.618	0.967	0.618
1.000	0.314	1.000	0.434	1.000	0.510	1.000	0.677	1.000	0.637
1.033	0.275	1.033	0.442	1.033	0.528	1.033	0.686	1.033	0.637

Appendix 5: Damian Lillard shooting hand average

Hand Average	
Time (s)	Height (m)
t	y
0.000	1.530
0.033	1.652
0.067	1.762
0.100	1.848
0.133	1.901
0.167	1.976
0.200	2.091
0.233	2.164
0.267	2.259
0.300	2.353
0.333	2.425
0.367	2.397
0.400	2.369
0.433	2.346
0.467	2.317
0.500	2.257
0.533	2.170
0.567	2.091
0.600	2.017
0.633	1.930
0.667	1.711
0.700	1.584
0.733	1.434
0.767	1.324
0.800	1.206
0.833	1.113
0.867	1.041
0.900	1.020
0.933	1.050
0.967	1.079
1.000	1.109
1.033	1.134

Appendix 6: Damian Lillard knee average

Knee Average	
Time (s)	Height (m)
t	y
0.000	0.482
0.033	0.445
0.067	0.385
0.100	0.392
0.133	0.392
0.167	0.395
0.200	0.403
0.233	0.410
0.267	0.427
0.300	0.416
0.333	0.430
0.367	0.450
0.400	0.473
0.433	0.514
0.467	0.549
0.500	0.612
0.533	0.647
0.567	0.688
0.600	0.696
0.633	0.701
0.667	0.663
0.700	0.614
0.733	0.563
0.767	0.533
0.800	0.490
0.833	0.451
0.867	0.451
0.900	0.439
0.933	0.453
0.967	0.487
1.000	0.514
1.033	0.514

Appendix 7: My shooting hand before shifting

Hand 1		Hand 2		Hand 3		Hand 4		Hand 5	
Time (s)	Height (m)	Time (s)	Height (m)	Time (s)	Height (m)	Time (s)	Height (m)	Time (s)	Height (m)
Hand_1	Hand_1	Hand_2	Hand_2	Hand_3	Hand_3	Hand_4	Hand_4	Hand_5	Hand_5
t	y	t	y	t	y	t	y	t	y
2.100	0.744	10.966	0.708	19.700	0.750	34.566	0.841	47.166	0.770
2.133	0.770	11.000	0.793	19.733	0.773	34.600	1.065	47.200	0.805
2.166	0.793	11.033	0.902	19.766	0.741	34.633	1.174	47.233	0.817
2.200	0.817	11.066	1.077	19.800	0.769	34.666	1.337	47.266	0.902
2.233	1.041	11.100	0.877	19.833	0.920	34.700	0.998	47.300	0.950
2.266	1.162	11.133	0.980	19.866	1.011	34.733	1.095	47.333	1.023
2.300	1.241	11.166	1.101	19.900	1.132	34.766	1.216	47.366	1.138
2.333	1.343	11.200	1.222	19.933	1.241	34.800	1.301	47.400	1.241
2.366	1.446	11.233	1.362	19.966	1.313	34.833	1.398	47.433	1.362
2.400	1.555	11.266	1.428	20.000	1.446	34.866	1.531	47.466	1.458
2.433	1.640	11.300	1.543	20.033	1.543	34.900	1.610	47.500	1.549
2.466	1.743	11.333	1.628	20.066	1.628	34.933	1.713	47.533	1.640
2.500	1.870	11.366	1.743	20.100	1.731	34.966	1.828	47.566	1.815
2.533	2.064	11.400	1.870	20.133	1.846	35.000	1.961	47.600	1.942
2.566	2.191	11.433	2.124	20.166	2.112	35.033	2.281	47.633	2.154
2.600	2.166	11.466	2.172	20.200	2.280	35.066	2.281	47.666	2.221
2.633	2.233	11.500	2.203	20.233	2.257	35.100	2.309	47.700	2.257
2.666	2.076	11.533	2.112	20.266	2.227	35.133	2.215	47.733	2.172
2.700	1.955	11.566	1.985	20.300	2.160	35.166	2.088	47.766	2.039
2.733	1.882	11.600	1.906	20.333	2.112	35.200	2.051	47.800	1.967
2.766	1.834	11.633	1.785	20.366	1.967	35.233	1.900	47.833	1.870
2.800	1.820	11.666	1.755	20.400	1.894	35.266	1.894	47.866	1.854
2.833	1.834	11.700	1.767	20.433	1.858	35.300	1.852	47.900	1.840
2.866	1.900	11.733	1.791	20.466	1.882	35.333	1.870	47.933	1.870
2.900	1.918	11.766	1.840	20.500	1.900	35.366	1.918	47.966	1.924
2.933	1.942	11.800	1.894	20.533	1.955	35.400	1.985	48.000	1.979
2.966	1.902	11.833	1.888	20.566	1.955	35.433	1.967	48.033	1.967
3.000	1.894	11.866	1.864	20.600	1.960	35.466	1.960	48.066	1.961
3.033	1.882	11.900	1.882	20.633	1.972	35.500	1.955	48.100	1.955
3.066	1.879	11.933	1.870	20.666	1.955	35.533	1.950	48.133	1.944
3.100	1.875	11.966	1.852	20.700	1.930	35.566	1.942	48.166	1.940
3.133	1.859	12.000	1.828	20.733	1.894	35.600	1.882	48.200	1.930
3.166	1.830	12.033	1.840	20.766	1.870	35.633	1.918	48.233	1.912
3.200	1.802	12.066	1.834	20.800	1.779	35.666	1.882	48.266	1.882
3.233	1.760	12.100	1.821	20.833	1.688	35.700	1.871	48.300	1.858
3.266	1.706	12.133	1.809	20.866	1.477	35.733	1.860	48.333	1.791
3.300	1.555	12.166	1.773	20.900	1.192	35.766	1.846	48.366	1.634
3.333	1.452	12.200	1.725	20.933	1.053	35.800	1.809	48.400	1.531
3.366	1.374	12.233	1.664	20.966	0.908	35.833	1.737	48.433	1.374
3.400	1.241	12.266	1.507	21.000	0.890	35.866	1.640	48.466	1.234

3.433	1.059	12.300	1.362	21.033	0.852	35.900	1.616	48.500	1.071
3.466	0.920	12.333	1.228	21.066	0.823	35.933	1.470	48.533	0.914

Appendix 8: My knee before shifting

Knee 1		**Knee 2**		**Knee 3**		**Knee 4**		**Knee 5**	
Time (s)	Height (m)	Time (s)	Height (m)	Time (s)	Height (m)	Time (s)	Height (m)	Time (s)	Height (m)
Knee_1	Knee_1	Knee_2	Knee_2	Knee_3	Knee_3	Knee_4	Knee_4	Knee_5	Knee_5
t	y	t	y	t	y	t	y	t	y
2.100	0.551	10.966	0.381	19.700	0.569	34.566	0.641	47.166	0.539
2.133	0.514	11.000	0.357	19.733	0.502	34.600	0.587	47.200	0.520
2.166	0.478	11.033	0.309	19.766	0.466	34.633	0.563	47.233	0.496
2.200	0.442	11.066	0.272	19.800	0.454	34.666	0.560	47.266	0.478
2.233	0.381	11.100	0.252	19.833	0.423	34.700	0.557	47.300	0.454
2.266	0.372	11.133	0.224	19.866	0.405	34.733	0.533	47.333	0.436
2.300	0.345	11.166	0.242	19.900	0.375	34.766	0.502	47.366	0.405
2.333	0.339	11.200	0.260	19.933	0.388	34.800	0.489	47.400	0.418
2.366	0.333	11.233	0.273	19.966	0.393	34.833	0.478	47.433	0.408
2.400	0.345	11.266	0.291	20.000	0.396	34.866	0.454	47.466	0.393
2.433	0.381	11.300	0.321	20.033	0.401	34.900	0.466	47.500	0.321
2.466	0.405	11.333	0.369	20.066	0.405	34.933	0.508	47.533	0.345
2.500	0.441	11.366	0.411	20.100	0.454	34.966	0.514	47.566	0.375
2.533	0.466	11.400	0.520	20.133	0.502	35.000	0.551	47.600	0.381
2.566	0.514	11.433	0.581	20.166	0.557	35.033	0.641	47.633	0.393
2.600	0.599	11.466	0.635	20.200	0.647	35.066	0.660	47.666	0.414
2.633	0.611	11.500	0.666	20.233	0.744	35.100	0.781	47.700	0.466
2.666	0.666	11.533	0.708	20.266	0.805	35.133	0.847	47.733	0.514
2.700	0.726	11.566	0.775	20.300	0.824	35.166	0.932	47.766	0.563
2.733	0.775	11.600	0.829	20.333	0.877	35.200	0.941	47.800	0.684
2.766	0.829	11.633	0.835	20.366	0.914	35.233	0.968	47.833	0.732
2.800	0.837	11.666	0.847	20.400	0.974	35.266	1.029	47.866	0.793
2.833	0.841	11.700	0.852	20.433	0.980	35.300	1.048	47.900	0.805
2.866	0.823	11.733	0.799	20.466	0.962	35.333	0.992	47.933	0.835
2.900	0.812	11.766	0.769	20.500	0.944	35.366	0.950	47.966	0.859
2.933	0.793	11.800	0.732	20.533	0.908	35.400	0.920	48.000	0.871
2.966	0.787	11.833	0.660	20.566	0.865	35.433	0.896	48.033	0.890
3.000	0.708	11.866	0.617	20.600	0.835	35.466	0.847	48.066	0.841
3.033	0.647	11.900	0.563	20.633	0.702	35.500	0.756	48.100	0.787
3.066	0.581	11.933	0.514	20.666	0.684	35.533	0.684	48.133	0.744
3.100	0.553	11.966	0.405	20.700	0.605	35.566	0.660	48.166	0.696
3.133	0.502	12.000	0.393	20.733	0.575	35.600	0.599	48.200	0.690
3.166	0.472	12.033	0.375	20.766	0.502	35.633	0.514	48.233	0.612
3.200	0.430	12.066	0.381	20.800	0.478	35.666	0.551	48.266	0.575
3.233	0.454	12.100	0.387	20.833	0.490	35.700	0.563	48.300	0.563
3.266	0.502	12.133	0.454	20.866	0.502	35.733	0.571	48.333	0.502

3.300	0.557	12.166	0.441	20.900	0.539	35.766	0.587	48.366	0.484
3.333	0.560	12.200	0.436	20.933	0.551	35.800	0.593	48.400	0.496
3.366	0.569	12.233	0.430	20.966	0.563	35.833	0.599	48.433	0.502
3.400	0.578	12.266	0.419	21.000	0.605	35.866	0.587	48.466	0.520
3.433	0.563	12.300	0.391	21.033	0.599	35.900	0.574	48.500	0.533
3.466	0.526	12.333	0.381	21.066	0.581	35.933	0.569	48.533	0.563

Appendix 9: My shooting hand after shifting

Hand 1		**Hand 2**		**Hand 3**		**Hand 4**		**Hand 5**	
Time (s)	Height (m)	Time (s)	Height (m)	Time (s)	Height (m)	Time (s)	Height (m)	Time (s)	Height (m)
Hand_1	Hand_1	Hand_2	Hand_2	Hand_3	Hand_3	Hand_4	Hand_4	Hand_5	Hand_5
t	y	t	y	t	y	t	y	t	y
0.000	0.744	0.000	0.708	0.000	0.750	0.000	0.841	0.000	0.770
0.033	0.770	0.033	0.793	0.033	0.773	0.033	1.065	0.033	0.805
0.066	0.793	0.066	0.902	0.066	0.741	0.066	1.174	0.066	0.817
0.100	0.817	0.100	1.077	0.100	0.769	0.100	1.337	0.100	0.902
0.133	1.041	0.133	0.877	0.133	0.920	0.133	0.998	0.133	0.950
0.166	1.162	0.166	0.980	0.166	1.011	0.166	1.095	0.166	1.023
0.200	1.241	0.200	1.101	0.200	1.132	0.200	1.216	0.200	1.138
0.233	1.343	0.233	1.222	0.233	1.241	0.233	1.301	0.233	1.241
0.266	1.446	0.266	1.362	0.266	1.313	0.266	1.398	0.266	1.362
0.300	1.555	0.300	1.428	0.300	1.446	0.300	1.531	0.300	1.458
0.333	1.640	0.333	1.543	0.333	1.543	0.333	1.610	0.333	1.549
0.366	1.743	0.366	1.628	0.366	1.628	0.366	1.713	0.366	1.640
0.400	1.870	0.400	1.743	0.400	1.731	0.400	1.828	0.400	1.815
0.433	2.064	0.433	1.870	0.433	1.846	0.433	1.961	0.433	1.942
0.466	2.191	0.466	2.124	0.466	2.112	0.466	2.281	0.466	2.154
0.500	2.166	0.500	2.172	0.500	2.280	0.500	2.281	0.500	2.221
0.533	2.233	0.533	2.203	0.533	2.257	0.533	2.309	0.533	2.257
0.566	2.076	0.566	2.112	0.566	2.227	0.566	2.215	0.566	2.172
0.600	1.955	0.600	1.985	0.600	2.160	0.600	2.088	0.600	2.039
0.633	1.882	0.633	1.906	0.633	2.112	0.633	2.051	0.633	1.967
0.666	1.834	0.666	1.785	0.666	1.967	0.666	1.900	0.666	1.870
0.700	1.820	0.700	1.755	0.700	1.894	0.700	1.894	0.700	1.854
0.733	1.834	0.733	1.767	0.733	1.858	0.733	1.852	0.733	1.840
0.766	1.900	0.766	1.791	0.766	1.882	0.766	1.870	0.766	1.870
0.800	1.918	0.800	1.840	0.800	1.900	0.800	1.918	0.800	1.924
0.833	1.942	0.833	1.894	0.833	1.955	0.833	1.985	0.833	1.979
0.866	1.902	0.866	1.888	0.866	1.955	0.866	1.967	0.866	1.967
0.900	1.894	0.900	1.864	0.900	1.960	0.900	1.960	0.900	1.961
0.933	1.882	0.933	1.882	0.933	1.972	0.933	1.955	0.933	1.955
0.966	1.879	0.966	1.870	0.966	1.955	0.966	1.950	0.966	1.944
1.000	1.875	1.000	1.852	1.000	1.930	1.000	1.942	1.000	1.940
1.033	1.859	1.033	1.828	1.033	1.894	1.033	1.882	1.033	1.930

1.066	1.830	1.066	1.840	1.066	1.870	1.066	1.918	1.066	1.912
1.100	1.802	1.100	1.834	1.100	1.779	1.100	1.882	1.100	1.882
1.133	1.760	1.133	1.821	1.133	1.688	1.133	1.871	1.133	1.858
1.166	1.706	1.166	1.809	1.166	1.477	1.166	1.860	1.166	1.791
1.200	1.555	1.200	1.773	1.200	1.192	1.200	1.846	1.200	1.634
1.233	1.452	1.233	1.725	1.233	1.053	1.233	1.809	1.233	1.531
1.266	1.374	1.266	1.664	1.266	0.908	1.266	1.737	1.266	1.374
1.300	1.241	1.300	1.507	1.300	0.890	1.300	1.640	1.300	1.234
1.333	1.059	1.333	1.362	1.333	0.852	1.333	1.616	1.333	1.071
1.366	0.920	1.366	1.228	1.366	0.823	1.366	1.470	1.366	0.914

Appendix 10: My knee after shifting

Knee 1		**Knee 2**		**Knee 3**		**Knee 4**		**Knee 5**	
Time (s)	Height (m)	Time (s)	Height (m)	Time (s)	Height (m)	Time (s)	Height (m)	Time (s)	Height (m)
Knee_1	Knee_1	Knee_2	Knee_2	Knee_3	Knee_3	Knee_4	Knee_4	Knee_5	Knee_5
t	y	t	y	t	y	t	y	t	y
0.000	0.551	0.000	0.381	0.000	0.569	0.000	0.641	0.000	0.539
0.033	0.514	0.033	0.357	0.033	0.502	0.033	0.587	0.033	0.520
0.066	0.478	0.066	0.309	0.066	0.466	0.066	0.563	0.066	0.496
0.100	0.442	0.100	0.272	0.100	0.454	0.100	0.560	0.100	0.478
0.133	0.381	0.133	0.252	0.133	0.423	0.133	0.557	0.133	0.454
0.166	0.372	0.166	0.224	0.166	0.405	0.166	0.533	0.166	0.436
0.200	0.345	0.200	0.242	0.200	0.375	0.200	0.502	0.200	0.405
0.233	0.339	0.233	0.260	0.233	0.388	0.233	0.489	0.233	0.418
0.266	0.333	0.266	0.273	0.266	0.393	0.266	0.478	0.266	0.408
0.300	0.345	0.300	0.291	0.300	0.396	0.300	0.454	0.300	0.393
0.333	0.381	0.333	0.321	0.333	0.401	0.333	0.466	0.333	0.321
0.366	0.405	0.366	0.369	0.366	0.405	0.366	0.508	0.366	0.345
0.400	0.441	0.400	0.411	0.400	0.454	0.400	0.514	0.400	0.375
0.433	0.466	0.433	0.520	0.433	0.502	0.433	0.551	0.433	0.381
0.466	0.514	0.466	0.581	0.466	0.557	0.466	0.641	0.466	0.393
0.500	0.599	0.500	0.635	0.500	0.647	0.500	0.660	0.500	0.414
0.533	0.611	0.533	0.666	0.533	0.744	0.533	0.781	0.533	0.466
0.566	0.666	0.566	0.708	0.566	0.805	0.566	0.847	0.566	0.514
0.600	0.726	0.600	0.775	0.600	0.824	0.600	0.932	0.600	0.563
0.633	0.775	0.633	0.829	0.633	0.877	0.633	0.941	0.633	0.684
0.666	0.829	0.666	0.835	0.666	0.914	0.666	0.968	0.666	0.732
0.700	0.837	0.700	0.847	0.700	0.974	0.700	1.029	0.700	0.793
0.733	0.841	0.733	0.852	0.733	0.980	0.733	1.048	0.733	0.805
0.766	0.823	0.766	0.799	0.766	0.962	0.766	0.992	0.766	0.835
0.800	0.812	0.800	0.769	0.800	0.944	0.800	0.950	0.800	0.859
0.833	0.793	0.833	0.732	0.833	0.908	0.833	0.920	0.833	0.871
0.866	0.787	0.866	0.660	0.866	0.865	0.866	0.896	0.866	0.890
0.900	0.708	0.900	0.617	0.900	0.835	0.900	0.847	0.900	0.841

0.933	0.647	0.933	0.563	0.933	0.702	0.933	0.756	0.933	0.787
0.966	0.581	0.966	0.514	0.966	0.684	0.966	0.684	0.966	0.744
1.000	0.553	1.000	0.405	1.000	0.605	1.000	0.660	1.000	0.696
1.033	0.502	1.033	0.393	1.033	0.575	1.033	0.599	1.033	0.690
1.066	0.472	1.066	0.375	1.066	0.502	1.066	0.514	1.066	0.612
1.100	0.430	1.100	0.381	1.100	0.478	1.100	0.551	1.100	0.575
1.133	0.454	1.133	0.387	1.133	0.490	1.133	0.563	1.133	0.563
1.166	0.502	1.166	0.454	1.166	0.502	1.166	0.571	1.166	0.502
1.200	0.557	1.200	0.441	1.200	0.539	1.200	0.587	1.200	0.484
1.233	0.560	1.233	0.436	1.233	0.551	1.233	0.593	1.233	0.496
1.266	0.569	1.266	0.430	1.266	0.563	1.266	0.599	1.266	0.502
1.300	0.578	1.300	0.419	1.300	0.605	1.300	0.587	1.300	0.520
1.333	0.563	1.333	0.391	1.333	0.599	1.333	0.574	1.333	0.533
1.366	0.526	1.366	0.381	1.366	0.581	1.366	0.569	1.366	0.563

Appendix 11: My shooting hand average

Hand Average	
Time (s)	Height (m)
t	y
0.000	0.763
0.033	0.841
0.066	0.885
0.100	0.980
0.133	0.957
0.166	1.054
0.200	1.165
0.233	1.270
0.266	1.376
0.300	1.484
0.333	1.577
0.366	1.670
0.400	1.797
0.433	1.936
0.466	2.172
0.500	2.224
0.533	2.252
0.566	2.160
0.600	2.045
0.633	1.984
0.666	1.871
0.700	1.844
0.733	1.830
0.766	1.863
0.800	1.900

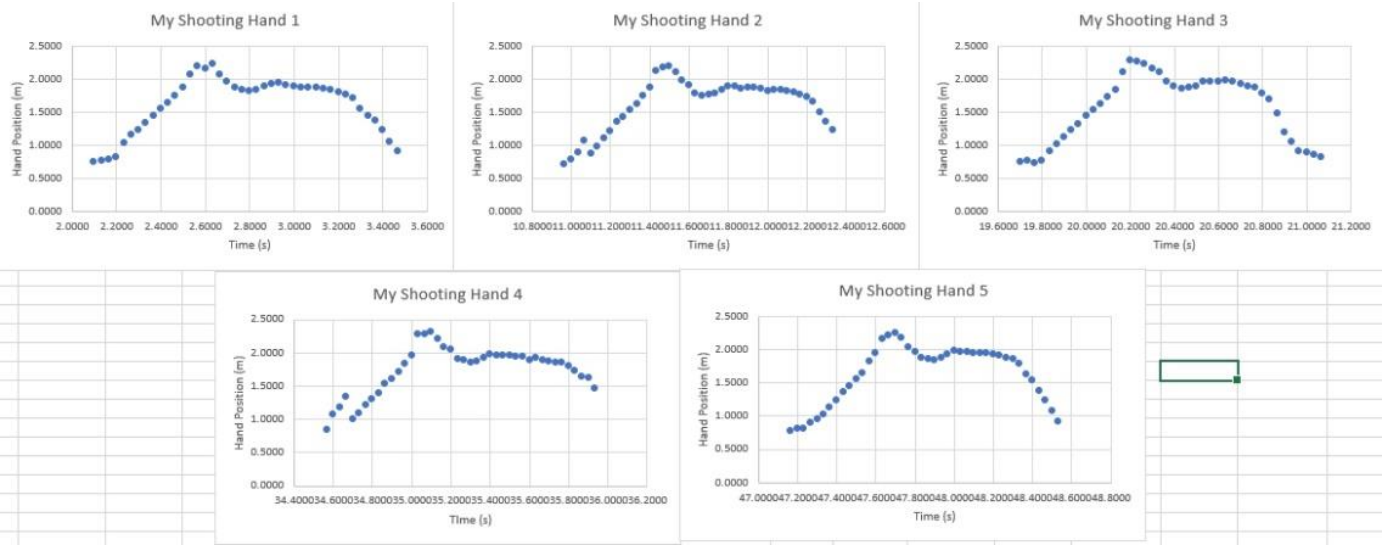
0.833	1.951
0.866	1.936
0.900	1.928
0.933	1.929
0.966	1.920
1.000	1.908
1.033	1.879
1.066	1.874
1.100	1.836
1.133	1.800
1.166	1.729
1.200	1.600
1.233	1.514
1.266	1.411
1.300	1.302
1.333	1.192
1.366	1.071

Appendix 12: My knee average

Knee Average	
Time (s)	Height (m)
t	y
0.000	0.536
0.033	0.496
0.066	0.462
0.100	0.441
0.133	0.413
0.166	0.394
0.200	0.374
0.233	0.379
0.266	0.377
0.300	0.376
0.333	0.378
0.366	0.407
0.400	0.439
0.433	0.484
0.466	0.537
0.500	0.591
0.533	0.654
0.566	0.708
0.600	0.764
0.633	0.821
0.666	0.856

0.700	0.896
0.733	0.905
0.766	0.882
0.800	0.867
0.833	0.845
0.866	0.819
0.900	0.770
0.933	0.691
0.966	0.641
1.000	0.584
1.033	0.552
1.066	0.495
1.100	0.483
1.133	0.491
1.166	0.506
1.200	0.522
1.233	0.527
1.266	0.533
1.300	0.542
1.333	0.532
1.366	0.524

Appendix 13: My shooting hand movement



Appendix 14: My shooting hand movement horizontally shifted

Appendix 15: Comparison of my shooting percentage and Damian Lillard's

Name	Number of attempted shots	Number of jump shots made	Shooting Percentage (%)
Damian Lillard	16	11	68.8%
Me	16	4	25.0%