THE DEVELOPMENT OF MULTIPLE LINEAR REGRESSION EQUATIONS TO PREDICT ACCURACY IN BASKETBALL JUMP SHOOTING

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Over the past few decades the jump shot has become the most potent scoring threat in the game of basketball. Its perfection has eliminated the need to score from long distances because it allows shots to be taken closer to the basket and therefore at a greater level of accuracy. Allsen (1967) reporting on the frequency of shots, (other than by lay-ups and tap-ins), found that the jump shot was used more than 67% of the time; the one hand set shot 21%, and right hand hook shot 8% and the left hand hook shot 2% of the time. Such information readily identifies the importance of the jump shot to the game of basketball. Several authors including Wilkes (1965), Cousy (1973), Brotherson (1972), and Sharman (1968), have analyzed this technique subjectively, but there is little evidence to support the claims of these analysts. More recent studies such as Penrose and Blanksby (1976) have attempted to determine differences between excellent and poor shooters. However, a clear cut identification of the variables that determine performance differences has not been accomplished.

The present study involved cinema-computer and Multiple Linear Regression analyses to determine the factors that account for a significant portion of the variance in the execution of the jump shot from ten and twenty feet. Subjects (S's) represented the entire spectrum of skill, ranging from excellent to poor. This study examined the following questions:

1. What factors account for the variance in accuracy at ten feet?
2. What factors account for the variance in accuracy at twenty feet?
3. Are the factors the same at each distance?

METHODS

Selection of Subjects

Forty-two S's were tested to determine their shooting ability. The testing consisted of one hundred jump shots, in sets of ten, taken from both ten and twenty feet directly in front of the basket. From these S's, fifteen were selected for film analysis. These S's provided a range of shooting ability from inaccurate (5%), to high percentage (82%) and demontrated performance consistency between sets of shots. With such a continuum of shooters, isolating and predicting key factors in performing this skill was thought to be more attainable.

Data Collection

The data collection took place on three separate days for all S's. The initial testing, (accuracy for 100 shots at each distance) took place over a period of two weeks. The filming was done on two successive days. The first day, shooting trials from ten feet were filmed, and the second day trials from twenty feet were filmed.

Cinematographic Procedures

The film analysis included by-plane cinematography with the frontal and lateral planes being used. A Locam 16mm high speed camera (model 51 D.C.) was used to film the lateral perspective. Because only right handed shooters were used in the study this camera was placed to the right of the S's so that the shooting arm was readily visible. This film was used in the cinema computer analysis.

A Bolex model H16, 16mm spring wound motion picture camera was used to film the frontal view. This camera was below the basket and the film it produced was used to make selected frontal measurements. These measurements included information concerning spatial relationships between body segments and the ball, and their alignment in the saggital plane.

Both cameras were mounted on tripods and were set perpendicular to and at right angles with the filming area and the floor. In the trials from ten and twenty feet the Locam was 30 feet from the S, while the Bolex was set at nineteen and twenty-one feet from the S's, respectively. Both cameras were 4.5 feet above the gymansium floor (Figure 1).

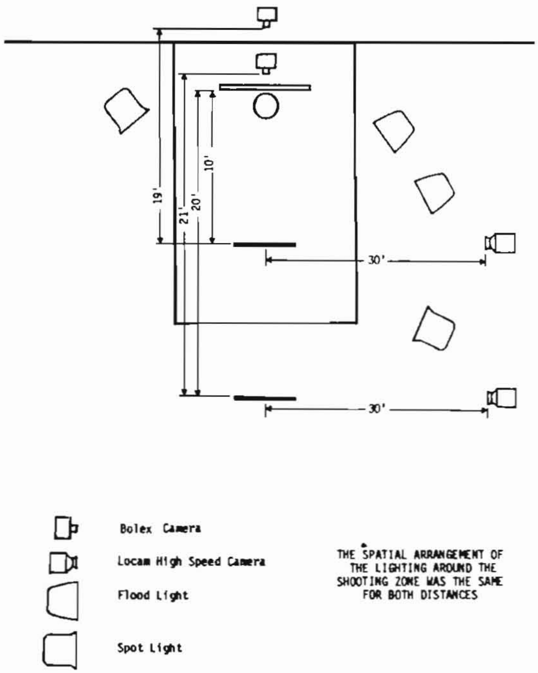

Figure 1
Arrangement of Equipment for Filming Sessions

The film used was black and white Kodak 4X Reversal, 7277, 16mm film. Both the Bolex and the Locam used film with an emulsion speed of ASA-400.

The camera speeds were verified in two ways. The Bolex and the Locam were set at 64 and 128 frames per second respectively. Both cameras were used to film an electric clock divided into hundredths of a second. This was the only check on the film speed in the Bolex whereas it served as a second check on the internal timing light in the Locam.

The linear scale was recorded by filming a board, marked in twelve inch segments, in the centre of the filming zone. This was verified by marking a six inch segment on each S. As well as allowing scale to be determined, suspension of the board provided a vertical reference when the film was projected.

With the S at the shooting position, a signal was given for the cameras to start, permitting them to reach the desired speed once the shooting portion of the action began. The filming began by means of a hand signal and the digitizing was carried out starting with the frame in which the S's centre of gravity was at its lowest point. The last frame digitized was after the ball left the S's hand, and included two digitized frames of ball flight.

DATA ANALYSIS

Cinema-computer analysis and forward stepwise multiple linear regression (MLR) analysis were used to analyze the data. MLR builds an equation which will predict a dependent variable (shooting accuracy) from a combination of independent variables (34 factors measured from lateral and frontal perspective films).

Since the maximum number of variables which the program will admit to the equation is the number of subjects minus one (n-1), it was decided that only the most important n-1 of the 34 variables should be submitted to each analysis. The selection of these variables was accomplished by analyzing the intercorrelation matrix among the independent variables. Significant intercorrelations were identified and those highly related were noted. Selection from among those variables for submission into the equation was based on the degree of correlation with the dependent variable and the ease and accuracy of measurement. From each group of highly related variables only one was selected for input into the MLR program.

RESULTS

Five of the 14 independent variables accounted for 92.71% of the variance in shooting accuracy from 10 feet; and an equal number accounted for 85.98% of the variance in accuracy at 20 feet. Interestingly, four of the top five variables were common to both equations. It was decided that another pair of equations be determined using only the four common independent variables:

1. Var 13, the release angle of the shoulder (lateral view).
2. Var 9, the starting angle of the elbow (lateral view).
3. Var 22, the upper arm in relation to the vertical at release (frontal view).
4. Var 30, the amount of ball spin (frontal view).

Variables 13 and 9 as well as the CG displacement can be seen in Fig. 2; Var. 22 can be seen in Fig. 3. The four variables mentioned formed a significant equation accounting for 85.07% of the variance at ten feet (Table 1).

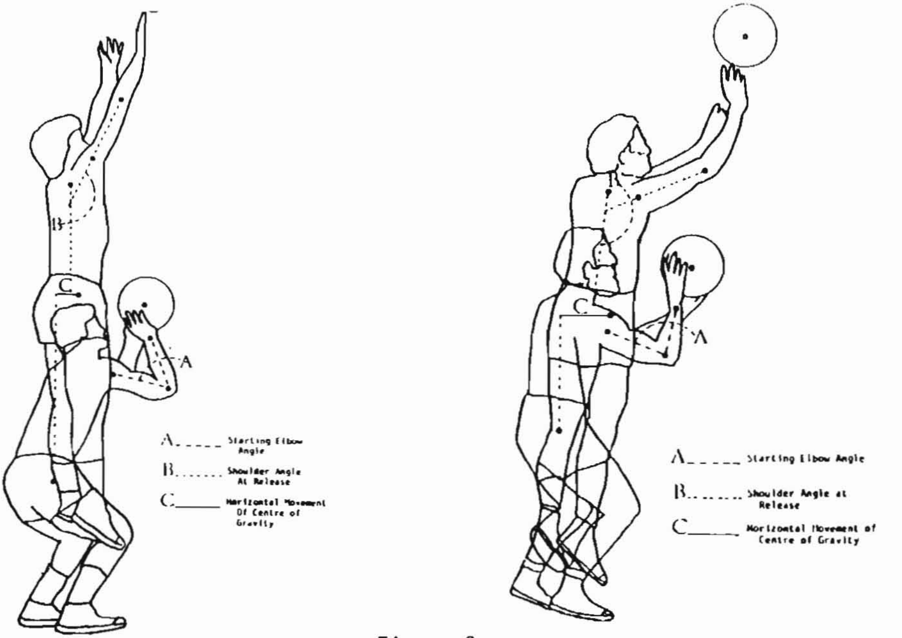

Figure 2
Independent Variables From Lateral Perspective

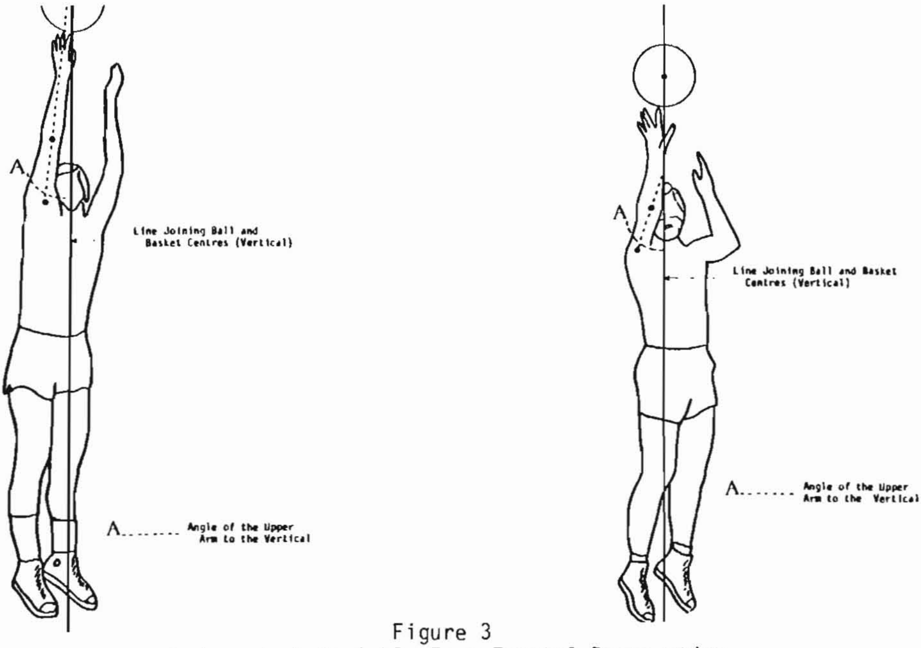

Figure 3
Independent Variable From Frontal Perspective

TABLE 1
COMMON PREDICTORS IN THE SIGNIFICANT EQUATIONS FROM 10 AND 20 FT.

Regression Analysis for Data From 10ft
Dependent Variable - Shooting Accuracy

Variable	Significance	Multiple R	R Square X 100%	R Square Change x 100%	Simple R	Overall F	Significance
1 VAR 13	.000	.812	65.97	65.97	.812	25.20	.001
2 VAR 09	.022	.885	78.38	12.41	-.777	21.76	.001
3 VAR 22	.104	.912	83.18	04.79	.658	18.13	.001
4 VAR 30	.287	.922	85.07	01.89	-.613	14.25	.001

Regression Equation formed with the first 4 variables (Significance = .000)

Estimated Score = .409 (VAR 13) - .719 (VAR 09) = 13.8 (VAR 22) - 25.79 (VAR 30) + 76.89

The same four variables formed a significant equation accounting for 80.32% of the variance at 20 Ft. (Table 2).

TABLE 2
COMMON PREDICTORS IN THE SIGNIFICANT EQUATIONS FROM 10 AND 20 FT.

Regression Analysis for Data From 20ft
Dependent Variable - Shooting Accuracy

Variable	Significance	Multiple R	R Square X 100%	R Square Change x 100%	Simple R	Overall F	Significance
1 VAR 22	.002	.729	53.15	53.15	.729	14.75	.002
2 VAR 30	.030	.830	68.92	15.77	-.536	13.30	.001
3 VAR 13	.095	.872	76.17	07.24	.462	11.72	.001
4 VAR 09	.177	.896	80.32	04.14	-.628	10.20	.001

Regression Equation formed with the first 4 variables (Significance = .001)

Estimated Score = .84 (VAR 22) - 69.06 (VAR 30) + .969 (VAR 13) - .485 (VAR 09) - 54.4

DISCUSSION

The two final regression analyses reveal that four factors can account for a significant (80%-85%) amount of variance in jump shooting accuracy from 10 and 20 feet. The more successful shooters demonstrated both a greater angle of elbow flexion at the initiation of the shooting motion, and a greater angle of the shoulder to the trunk at release. This increased range of motion at the elbow (release angle at or near 180°) and shoulder resulted in a more vertical angle of ball projection and consequently more of an opening in the rim for the ball to pass through on its descent. By having predominantly a vertical rise of the body's CG and by releasing prior to the termination of that motion; the body, shoulder, elbow, wrist and hand all contributed to the projection of the ball, and caused it to fly with greater backward spin toward the target.

These factors together with the proper shoulder alignment from the frontal view resulted in a nearer to vertical upper arm at release from all perspective. "Squaring up" to the target is obviously not the proper starting or finishing objective when shooting the jump shots. Subsequent foul shooting studies at Dalhousie have yielded similar results relative to the rotation of the body around its long axis and the proper initial positioning and movement of the shoulder girdle and shoulder joint.

CONCLUSIONS

The following factors were found to be associated with performance of the jump shot from 10 and 20 feet as demonstrated by our S's in this study:

1. More successful shooters demontrated a greater angle at the shoulder at the point of releasing the basketball (lateral view).

2. More successful shooters used a much smaller elbow angle at the start of the shot than the poorer performers.

3. A greater back spin during flight was associated with the high performance shooters.

4. The successful shooters demonstrated a closer alignment of the upper arm with the vertical at release, than the lower percentage shooters.

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