THE RELATIONSHIP BETWEEN KINEMATIC VARIABLES AND SHOOTING DISTANCE IN BASKETBALL: A RE-EVALUATION

Stuart A. Miller

Cardiff Institute of Higher Education, Cardiff, Wales.

INTRODUCTION

Basketball tactics have evolved such that all team members are expected to contribute to scoring, and research has shown that players of the three major positions (guard, forward and centre) tend to play in different areas of the court (Miller and Bartlett, in press). It is, thus, reasonable to assume that players of different positions attempt shots from these respective areas and, therefore, different distances from the basket. Several studies have examined shooting technique at different distances from the basket (e.g. Miller and Bartlett, 1993), however, of this literature, none has utilised more than three distances (and several only two, e.g. Elliott and White, 1989). Not unexpectedly, the distances used tend to represent those common to the game, one of which is usually close to the largest expected during play i.e. the three-point shot (e.g. Elliott, 1992).

Whilst there is nothing intrinsically wrong with such research, a drawback with these protocols is that, whilst providing information as to the movement kinematics at each of the distances studied, an insight into the true nature of the relationship between kinematic variables and shooting distance is unlikely to be provided. Indeed, any attempt to do so would be, at best, highly speculative. For example, a study which compares kinematics at two shooting distances will have only those two levels of independent variable from which to infer relationships, leading to the inevitable conclusion that they are linear in nature. As such, it is open to question as to whether this objective is best served by such protocols. The objective of this paper is to assess an alternative analysis with which to examine the relationship between kinematic parameters and shooting distance in basketball.

METHODS

The data collection methodology for this study has previously been described (Miller and Bartlett, 1992). Eighteen successful shots were analysed, the shooting distances for which ranged from 0.9 m to 8.5 m. Distances from which shots were attempted were ascertained by comparison with markings of known distance on the court surface. A successful shot was defined as one which passed cleanly through the basket without contact with the backboard, as such contact would indicate an error/errors in release parameters. Sequences were digitised at 50 Hz, and analysed from 0.40 s prior to take-off to 0.20 s after ball release. Two key moments were identified:

- Take-off: the first field in which foot/ground contact was broken.
- Ball release: the first field in which hand/ball contact was broken.

A one-way analysis of variance (ANOVA) yielded non-significant F-ratios < 0.95 ($p < 0.05$) for selected parameters with respect to both objectivity and reliability.

In the original analysis of the data, the fifteen sequences selected for analysis were assigned to one of three groups based on shooting distance (0-3.66 m; 3.67-5.49 m; > 5.50 m) in order to represent the shooting ranges for centres, forwards and guards respectively. A one-way ANOVA was used to test for differences between groups. This revealed few significant differences, and led to speculation as to whether an alternative analysis could be applied which may better utilise the data. As the data were recorded during competition, the experimenter had no control over shooting distance and, as such, analysed shots were attempted from a wide range of distances. It was thus decided that a curve-fitting, as opposed to difference, analysis technique was appropriate. Quadratic curves were deemed appropriate as:

- whilst physical laws (e.g. projectile motion) provide a rationale for the utilisation of a quadratic function, there is no theoretical justification for applying curves of a higher order,
- should any relationship be linear in nature, then the coefficient of the squared function in the quadratic equation will be zero, and hence the linear nature of the relationship will still be evident.

Results were compared with those from the original three-group design.

RESULTS

The use of ANOVA techniques may be regarded as inappropriate for studies which attempt to ascertain the nature of the relationships between kinematic variables and shooting distance. This is because the rationale for such tests is to discover whether differences exist between data sets, whereas the objective of these studies is to determine the existence of relationships.

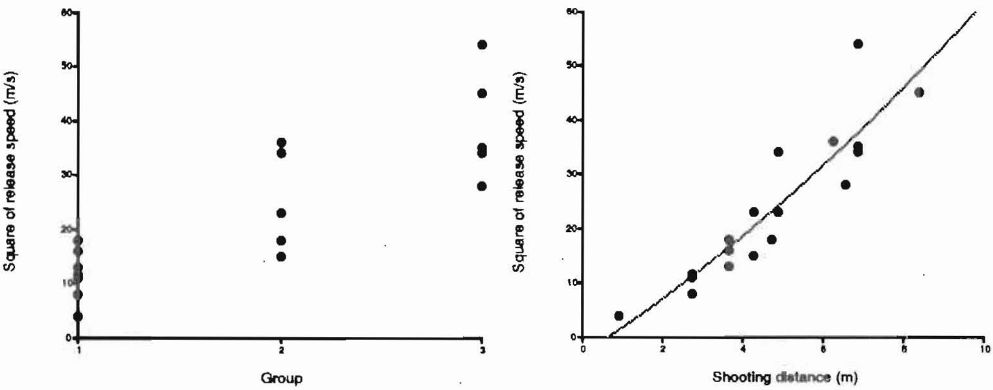

Figure 1. Shooting distance related to the square of release speed

Figure 1 shows, for both the original three group and current designs, the relationship between shooting distance and the square of release speed. The original ANOVA design (could only have) revealed a significant increase in the latter with respect to distance, whilst the current analysis suggests a slightly exponential trend, one which could not have been established by the former method. This may be unexpected as, all other factors being equal, range is directly proportional to the square of release speed. This would suggest that one or more other factors influence this relationship. Release angle may affect release speed, however, for the current data the relationship between these parameters was effectively zero. It is also well established that the release speed for any specific range is inversely related to the relative height of release, and as the trend between shooting distance and release height in this study was also inverse, it is suggested that the quadratic trend between shooting distance and the square of release speed is due, at least in part, to differences in release height.

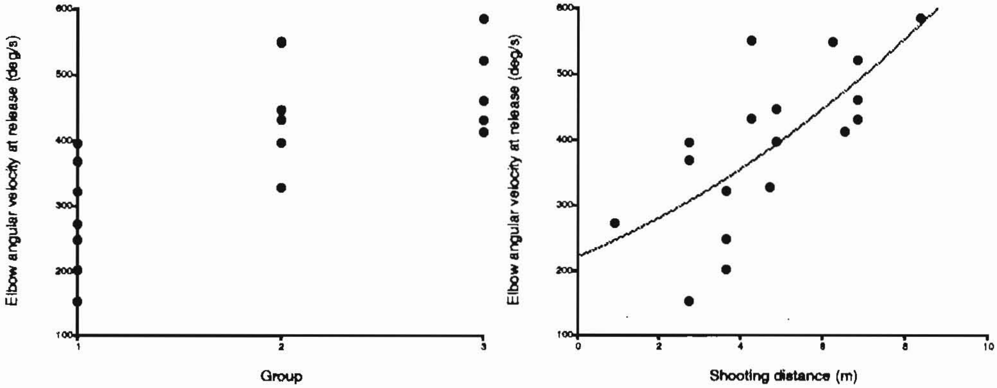

Figure 2. Angular velocity of the shooting elbow at release

Figure 2 demonstrates another problem which may be associated with a three group design. The left side of the diagram suggests that the relationship between elbow angular velocity not only increases with distance, but would also be convex upwards, whereas when shooting distance is accounted for, it can be seen that elbow angular velocity tends to increase exponentially with respect to time (i.e. concave upwards). If this parameter is a major contributor to ball release speed, as has previously been suggested (Miller and Bartlett, in press), then for it to mirror the relationship between ball release speed and distance may not be unexpected.

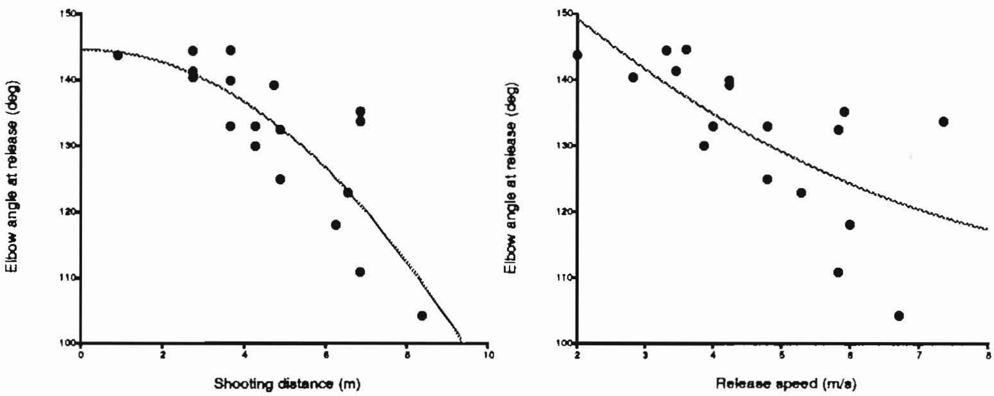

Figure 3. Angular displacement of the shooting elbow at release

Figure 3 demonstrates a further problem which may occur in analysis of this type of data. The curve relating elbow angular displacement to shooting distance clearly shows a curvilinear trend (convex upwards), whereas when the same parameter is plotted against release speed, the relationship, whilst still tending to be inverse, is seen to be concave upwards. Which is more appropriate? Whilst both show the nature of the relationship between the respective parameters, as an infinite number of release speeds and, therefore, elbow angles, can produce a successful shot at any single shooting distance, it would seem to be unwise to instruct a player that his/her elbow angle at release should be constant at any one distance. It would, however, be appropriate to relate changes in this parameter to release speed.

CONCLUSION

On the basis of the foregoing discussion, it was concluded that attempts to ascertain the true nature of the relationship between kinematic variables and shooting distance in basketball is likely to be erroneous using the traditional two-, and possible three-distance design.

Furthermore, for studies in which the objective is to examine the effects of shooting distance on kinematic variables, it is conceptually incorrect to use difference (e.g. ANOVA) techniques, as one is seeking to determine relationships as opposed to differences. It is recommended that curve-fitting, or correlation, techniques are appropriate in such cases.

It is not always instructive to analyse parameters with respect to shooting distance, as it has been demonstrated above that the same values for release speed can occur at different shooting distances.

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