VARIABILITY IN BASKETBALL SHOOTING: PRACTICAL IMPLICATIONS

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Basketball shooting is a dynamic, multi-segmental skill requiring considerable accuracy. The scientific and coaching literature advocate replication of movement patterns, although the extent to which this is achieved is not known. This also raises the question of whether inaccurate shots are characterised by greater variability than accurate shots. Finally, theoretical considerations suggest that long-range shots would be more variable than would short-range shots. As inaccurate free throws were characterised by greater variability in ball release speed and linear velocity at segment endpoints than accurate shots, coaches should stress the development of a consistent movement pattern. Greater variability in the same variables for long-range shots suggest that a ball release angle close to that requiring the minimum release speed would be advantageous.

KEY WORDS: Basketball shooting, kinematics, electromyography, variability

In many throwing activities, such as the shot put, the aim is to project an object as far as possible. This requires maximal effort by the athlete. It is also often the case that the outcome (score) is determined by the best single value of a series of trials, as in the javelin throw; only one well-performed trial is necessary. Another class of activities has the objective of accuracy. Here, an object is projected towards a target, and a score is awarded on either a binary scale - hit-miss - or a sliding scale, as in archery, in which a higher score is awarded for attempts that finish nearer a specific location. These movements are characterised by sub-maximal effort, and outcome is often dependent on the sum of performances over a series of attempts. Thus, the ability to generate the same (accurate) outcome consistently is important.

Basketball shooting requires considerable accuracy. A spherical ball of mass 0.6 kg and diameter 0.25 m must be projected through a horizontal circular hoop of diameter 0.45 m raised 3.05 m from the ground. An error in the sagittal or horizontal plane of ± 0.10 m from the ideal trajectory as the ball passes through the hoop will result in the ball making contact with, and possibly not passing through, the hoop. During a game, shots are normally attempted from distances up to 6.5 m. The relative margin for error in ball release speed in inversely related to shooting distance (Figure 1). As the relationships for both success rate and margin for error with shooting distance are similar, they would seem to be inter-related. What is unknown, however, is the extent to which other factors influence success.

Evidence can be found in the scientific literature that inter-trial consistency of movement patterns is linked to accuracy. For example, Higgins and Spaeth (1972) stated that, to maximise accuracy, a successful movement pattern should be developed and reproduced on each trial. Similar recommendations are implicit in the basketball coaching literature, especially for free throws (e.g. Wissel, 1994). This suggests that accurate movement patterns would be characterised by high inter-trial reproducibility. Furthermore, it may be inferred that deviation from a successful movement pattern would be a cause of inaccuracy. It has been established that movement variability is positively linked to impulse generated (Schmidt *et al*., 1979). As basketball shots from longer distances require greater impulse, then it would be expected that inter-trial variability is positively related to shooting distance.

The pertinent questions for basketball shooting are:

- To what extent are movement patterns for accurate shots reproducible?
- Are inaccurate shots characterised by lower reproducibility than accurate shots?
- Does reproducibility change for shots of different distances?

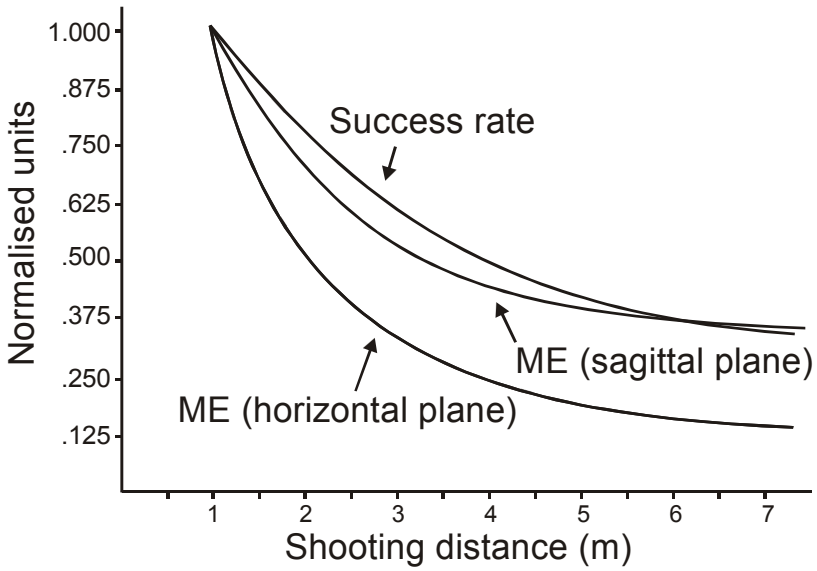

Figure 1 - The relationship between success rate (adapted from Bunn, 1955), margin for error (ME) and shooting distance.

The average intra-shooter coefficients of variation for the ball release parameters for accurate free throws are shown in Figure 2. It is clear that intra-shooter variability is not zero for any parameter, and that relative variability is inconsistent across the release parameters. Release height is the least variable of these, although it has the least effect on range of all the release parameters. Its consistency may be due, in part, to segment lengths, which are fixed. This indicates that skilled shooters are able to generate appropriate, and varying, combinations of ball release parameters.

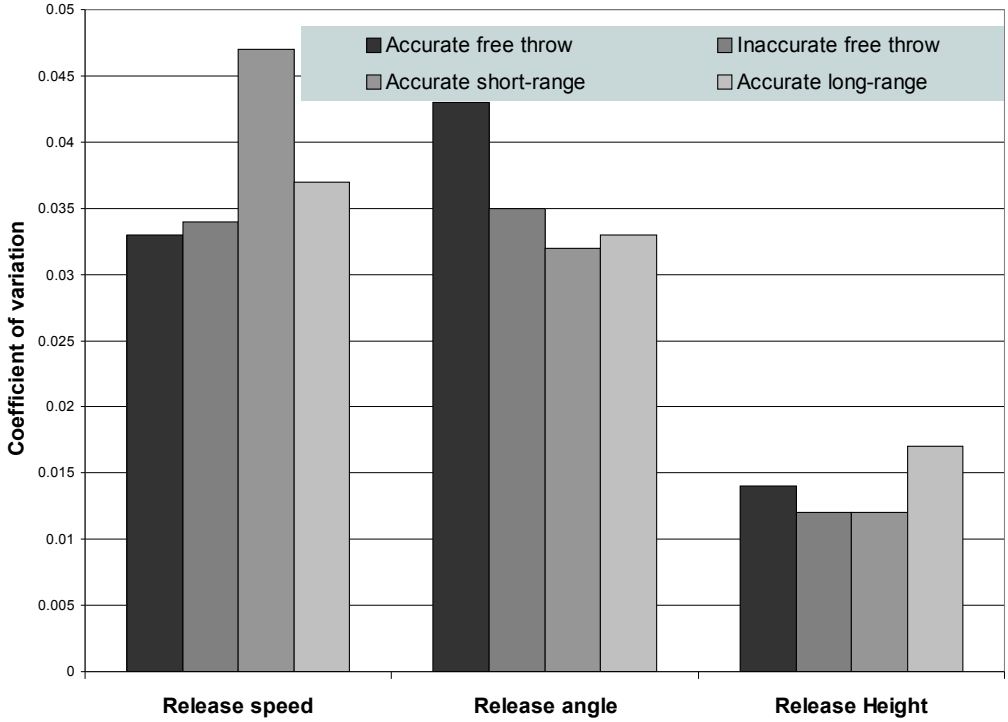

Figure 2 - Coefficients of variation for the primary ball release parameters for accurate and inaccurate free throws, and accurate short-range (2.74 m) and long-range (6.40 m) shots.

It is also evident from Figure 2 that support is equivocal for the theory that inaccurate shots are characterised by greater variability in the ball release parameters than accurate shots. The ball release speed for accurate shots was less than that for inaccurate shots; however, ball release angle and release height were more variable for accurate shots. Figure 2 also shows the variability for short-range and long-range shots. The effect of shooting distance on the release parameters is inconsistent. A greater than proportional increase in variability (with respect to the mean) for long-range shots is apparent for release angle and release height. The relative variability in ball release speed, however, is smaller for short-range shots, which may be an artefact of the greater allowable margin for error at shorter shooting distances.

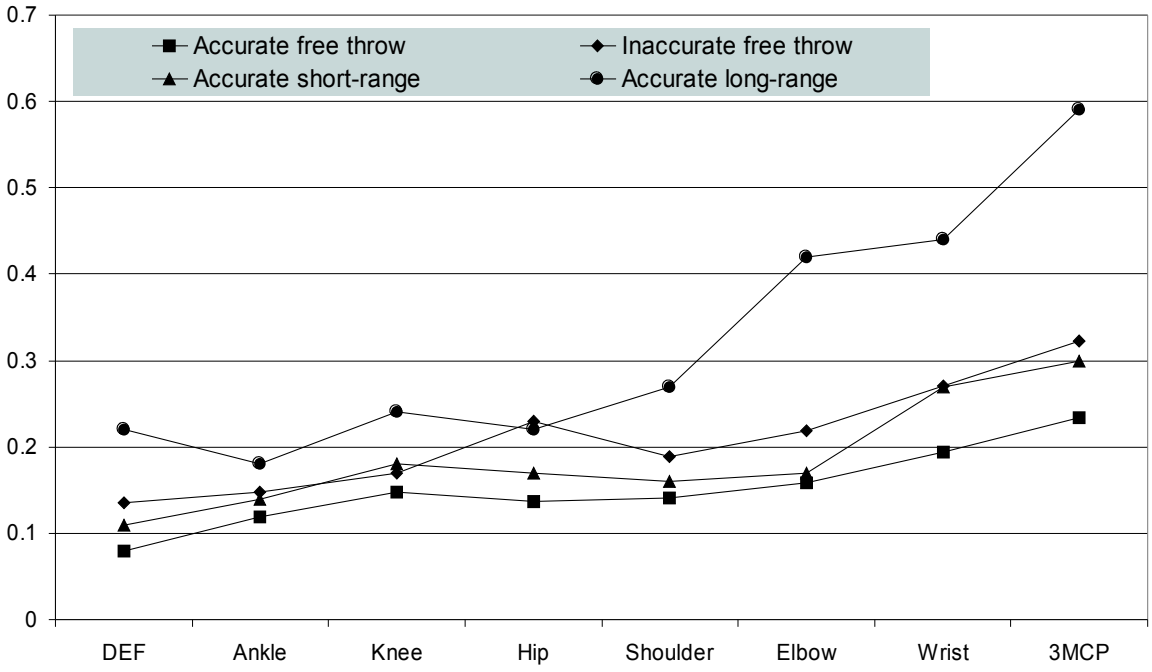

Figure 3 - Standard deviations of linear speeds at ball release for accurate and inaccurate free throws and accurate short-range (2.74 m) and long-range (6.40 m) shots.

Variability in ball release speed is a function of the variability in the linear speed of the segment endpoints. Figure 3 shows that, for all shots, variability tended to increase along the kinematic chain from the point of ground contact. It is clear that variability is present at all segment endpoints. Inaccurate free throws are characterised by greater absolute variability at all segment endpoints than are accurate attempts, which is consistent with the findings for ball release speed. There seems to be a link between the repeatability of movement patterns and success for free throws.

Impulse variability theory (Schmidt *et* al., 1979) is supported by the greater variability in the linear speed of all segment endpoints for long-range shots compared to short-range shots. The lower margin for error in ball release speed for longer shots (see Figure 1) is not the only factor that affects success rate. The lower variability in speed for accurate free throws than for short-range shots may be linked to shooters maintaining ground contact during free throws. This suggests that the impulse generated during the shot should be minimised.

In contrast to absolute variability, the relative variability of all shots tends to decrease along the kinematic chain from the point of ground contact (Figure 4). This may be indicative of an

organisational characteristic of the musculoskeletal system of skilled shooters, whereby variability at the endpoint of a distal segment (from the point of ground contact) tends to compensate for variability at its proximal neighbour. For all shooting distances, relative variability at segment endpoints further from the point of ground contact tends to converge to a value at the third metacarpophalangeal joint (3MCP) of about 0.1. It is possible that this is the minimum value that can be generated during basketball shooting. The relative variability in ball release speed is somewhat lower than that at 3MCP (see Figure 2), which suggests that compensation of variability also occurs between 3MCP and the ball.

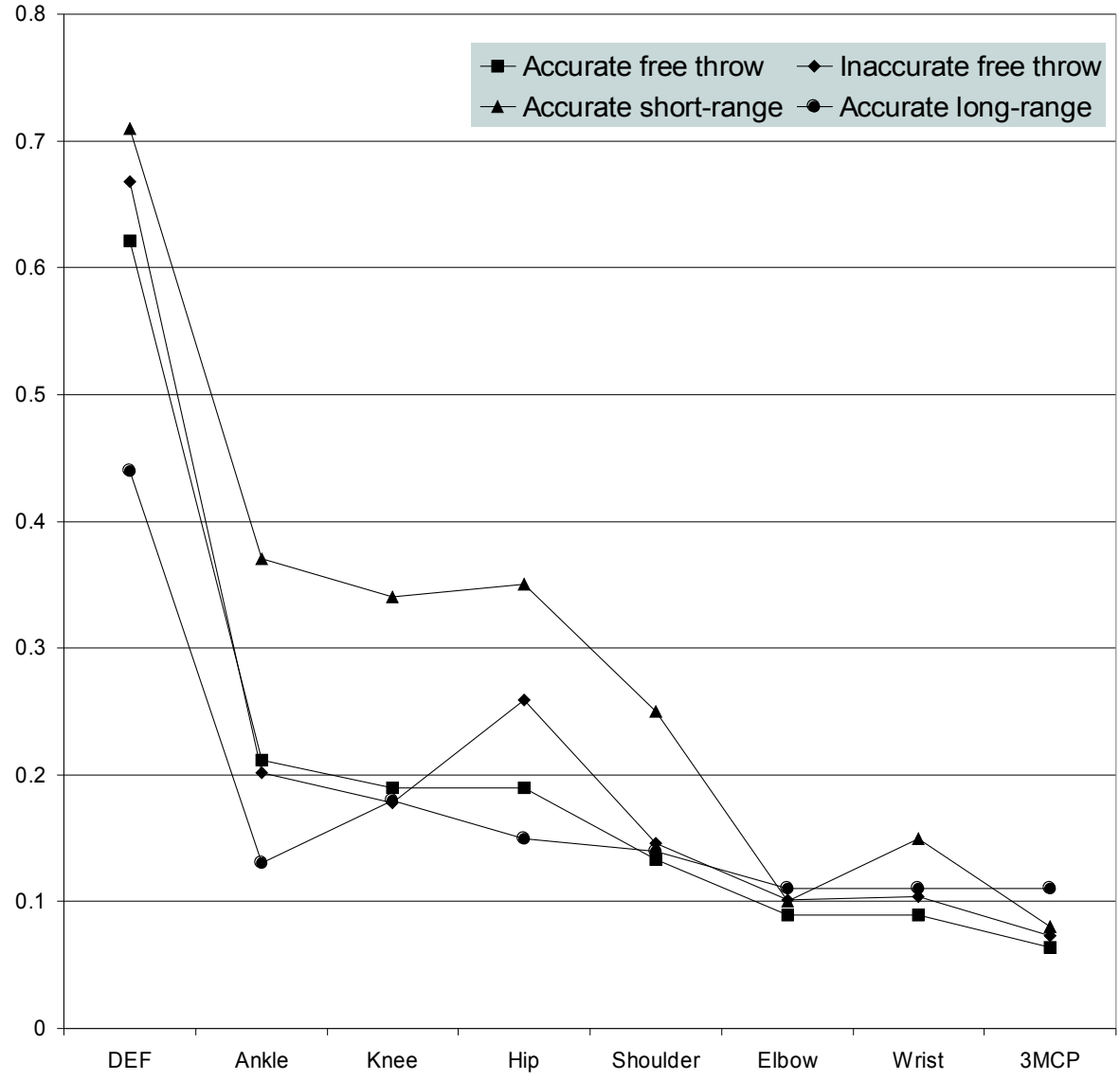

Figure 4 - Coefficients of variation of linear speeds at ball release for accurate and inaccurate free throws and accurate short-range (2.74 m) and long-range (6.40 m) shots.

CONCLUSION: Skilled basketball shooters are unable to generate identical inter-trial ball release parameters. However, inaccurate free throws are characterised by greater relative variability in ball release speed, and greater absolute variability in linear speed of segment endpoints at release. It seems, therefore, that coaches should emphasise the development of a consistent movement pattern.

The lower success rate for shots from longer range is a function of both the lower margin for error in ball release speed and the greater absolute variability associated with the generation of greater impulse. By releasing the ball close to the angle requiring the minimum ball release speed, shooters minimise the magnitude of the impulse that must be generated and, by implication, reduce variability in the movement.

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