ELECTROMYOGRAPHIC CONSIDERATIONS OF INACCURACY IN BASKETBALL SHOOTING

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The purpose of this study was to compare accurate and inaccurate basketball shots using selected electromyographic parameters. Thirteen participants attempted 3-point shots on a regulation basketball court until five successful and unsuccessful attempts had been made. Electromyographic data (1000 Hz) were gathered from six muscles (anteriorlposterior deltoid, bicepsltriceps brachii, flexor/extensor carpi radialis). Non-significant differences were found between temporal activation patterns. However, unsuccessful shots tended to be associated with a later activation, with respect to ball release, and a longer activation period. In 80% of all comparisons, unsuccessful shots were associated with greater variability, and the majority of parameters showed consistent differences between the mean values for successful and unsuccessful shots.

KEY WORDS: electromyography, basketball shooting, variability.

INTRODUCTION: A method by which sports movements may be grouped is the use of their performance criteria. For example, the objective in many athletic events (e.g., javelin, long jump) is maximisation of distance, whereas for high jump and pole vault, it is the height of projection. Such skills may be characterised as requiring maximisation of a particular variable (for example, take-off speed), and may be characterised as displacement-dominated. There is another class of movements for which outcome is accuracy-dominated. In these skills, there are several methods by which scores may be awarded, for example, a variable scale, which is dependent on the distance of a projectile from an optimum location (e.g., archery). Basketball shooting may be argued as having an even greater accuracy requirement, as points are awarded on an 'all-or-nothing' binary scale. Hence, attempts, in which deviations from the ideal range are sufficiently large for the ball not to pass through the hoop, are of little use. For example, an error in a range of 2% for a three-point shot will result in the ball making contact with the hoop. Of the published studies relating to basketball shooting, only that by Miller (1998) has considered inaccuracy. Results showed that, despite differences in variability between successful and unsuccessful shots, it was not always the case that unsuccessful shots were the more variable. In the primary release parameters, for example, there was greater variability in ball release angle for unsuccessful shots. However, successful shots were slightly more variable in terms of release speed. In general, the data suggested that variability was an unavoidable characteristic of basketball shooting. What could not be determined from kinematic data, however, was the contribution of the active musculature to, for example, the propagation of variability along the kinematic chain. Developing a greater understanding of variability would be a useful diagnostic tool by which the cause of persistent shooting inaccuracy may be identified. The aim of this study was to compare the characteristics of variability in kinetic parameters for successful and unsuccessful basketball shots.

METHOD: Thirteen right-handed participants (age, 21.9 ± 3.8 yrs; mass, 77.5 ± 10.3 kg; stature, 1.81 ± 0.09 m) volunteered for the study. All were experienced basketball players. Participants attempted shots on a regulation basketball court from a distance of 6.40 m, as described in Miller (1998), until each had scored and missed five shots. Electromyographic data were collected at 1000 Hz using two 4-channel MEGA ME3000P data loggers (common mode rejection ratio; > 130 dB) attached to the participants' waists. All procedures conformed to the recommendations of the British Association of Sport and Exercise Sciences (Burden and Bartlett, 1997). Electrode sites were prepared according to the procedure described by Okamoto, Tsutsumi, Goto, and Andrew (1987). Pre-gelled

Ag/AgCl electrodes, with a contact diameter of 1 cm, and an inter-electrode spacing of 3 cm, were placed on the belly of the contracted muscle (Clarys and Cabri, 1993). Connecting leads were taped to the participants' clothing where possible to reduce low frequency noise. The start and end of data collection were controlled by the experimenter using a switch connected to both data loggers. Care was taken that no tension was developed in the connecting wires. Recordings were made from the following agonist-antagonist muscle pairs: Anterior / Posterior deltoid (AD / PD); Triceps brachii [lateral head] / Biceps brachii (TB / BB); Flexor carpi radialis / Extensor carpi radialis (FCR / ECR). The raw signal was low-pass filtered (0-500 Hz) and amplified (gain = 393) before storage. The resulting electromyograms (EMGs) were full-wave rectified using a window width of 10 ms (Redfern, 1992), and the following parameters were determined for each attempt:

1. Contraction duration – the time from activation (i.e., when the amplitude of the rectified signal first reached 10 % of the maximum value) to relaxation (i.e., the final time when the amplitude of the rectified signal fell below 10 % of the maximum value).
2. Time from activation to ball release;
3. Median frequency for the contraction;
4. Average rectified EMG for the contraction; and
5. Integrated EMG – the product of contraction duration and average rectified EMG.

The window width selected for the calculation of median frequency, average rectified EMG and integrated EMG was that which was closest in duration to the muscle contraction, without exceeding it. Ball release was established from synchronised video records.
Mean values were calculated from the means of the five missed and scored shots for each participant, and then averaged across participants. Variability was quantified using standard deviation (SD) and coefficient of variation (CV) as absolute and relative measures respectively. Statistical comparisons were made between scores and misses for each muscle using a dependent t-test. Differences were insignificant unless stated otherwise. Dashes indicate instances where a meaningful coefficient of variation could not be calculated. All discussions of variability relate to SD unless otherwise stated.

RESULTS AND DISCUSSION: There were no significant differences between the mean contraction durations of scored (S) and missed (M) shots (Table 1). Despite this, greater values were found for missed shots in all muscles except extensor carpi radialis, the trend for which was almost wholly due to the results of a single participant. Greater variability was found for missed shots in those muscles crossing the shoulder and elbow, although differences were non-significant. A comparison of agonists and antagonists revealed the latter to be the more variable for both scores and misses.

Table 1 Contraction Duration (s)

	AD		PD		BB		TB		FCR		ECR	
	S	M	S	M	S	M	S	M	S	M	S	M
Mean	0.33	0.34	0.32	0.35	0.29	0.30	0.37	0.37	0.28	0.29	0.54	0.51
SD	0.08	0.09	0.10	0.15	0.09	0.10	0.09	0.11	0.09	0.08	0.18	0.18
CV	0.29	0.27	0.31	0.40	0.32	0.37	0.26	0.30	0.32	0.29	0.38	0.34

Table 2 shows that there were no significant differences between scores and misses for the time from muscle activation to ball release. In contrast with contraction duration, scored shots tended to have the larger mean values, indicating earlier activation. The combined effect of contraction duration and time from activation to release is shown schematically in Figure 1, which shows that the temporal activation patterns of scores and misses are offset.

Table 2 Time from Muscle Activation to Ball Release (s)

	AD		PD		BB		TB		FCR		ECR	
	S	M	S	M	S	M	S	M	S	M	S	M
Mean	0.30	0.28	0.22	0.21	0.17	0.17	0.29	0.26	0.20	0.19	0.37	0.35
SD	0.09	0.10	0.08	0.08	0.06	0.07	0.07	0.07	0.06	0.07	0.11	0.12
CV	0.30	0.31	---	---	---	0.44	0.26	0.25	0.39	---	0.51	0.41

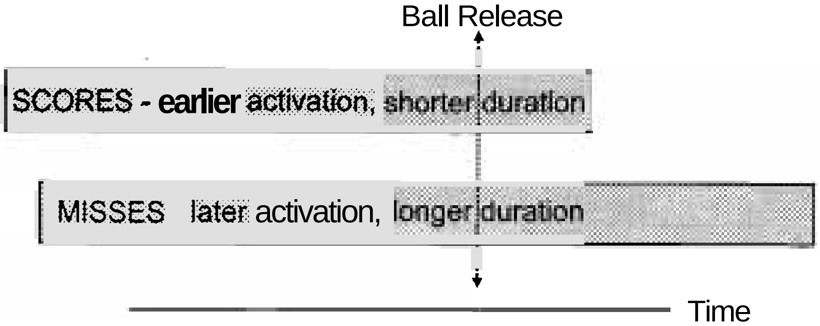

Figure 1 - A schematic representation of temporal activation patterns.

Table 3 shows that missed shots were associated with greater mean median frequencies for all muscles, the differences for posterior deltoid and biceps brachii being significant ($p < 0.05$). Variability was greater for misses in all muscles except extensor carpi radialis, and the differences for posterior deltoid were significant ($p < 0.05$). In addition to serving as shooting practice, the warm-up afforded to participants was designed to stabilise muscle fibre temperature. As such, any variability in median frequency is more likely to have been due to the recruitment of fibres with different conduction velocities as opposed to variation in the conduction velocity of active fibres. The coefficients of variation show median frequency to be the least variable of the parameters studied. That the most 'controllable' parameter is susceptible to variability, and that significant differences were found between scores and misses is regarded as supporting the notion that greater deviation from ideal (combinations of) muscle activation patterns are strongly related to inaccurate shooting.

Table 3 Median Frequency (Hz)

	AD		PD		BB		TB		FCR		ECR	
	S	M	S	M	S	M	S	M	S	M	S	M
Mean	61	64	49[1]	57[1]	51[3]	55[3]	73	74	80	83	133	134
S.D.	10.4	12.6	8.2[2]	11.4[2]	10.4	12.0	10.6	11.2	14.4	16.4	22.8	22.8
C.V.	0.17	0.20	0.17	0.20	0.22	0.23	0.15	0.15	0.19	0.21	0.18	0.18

Values with similar superscripts are significantly different from each other ($p < 0.05$).

Variability in the average EMG in this study is likely to be due mainly to the number and firing rates of active motor units. There were no significant differences between scores and misses for this parameter, partly because of the magnitudes of the SDs (Table 4), although variability for missed shots tended to be greater than for scored shots. It is useful to compare the relative variability patterns of median frequency and average rectified EMG, as the former is an indicator of the number of active fibres, while the latter is dependent on both the number of active fibres and their firing rates. For agonist-antagonist pairs crossing the shoulder and elbow, there were similar agonist (anterior deltoid and triceps brachii) values for these parameters, with greater values for average rectified EMG in their respective antagonists. At the wrist, however, this trend was reversed. Thus, it may be that, for muscles in which relative variabilities of median frequency and average rectified

EMG were similar (anterior deltoid, triceps brachii, extensor carpi radialis), variability is largely dependent on the number of active fibres. In those muscles (posterior deltoid, biceps brachii, flexor carpi radialis) which had greater relative variability in average rectified EMG, it may be that the firing rate of active fibres exerts a greater influence on variability.

Table 4 **Average Rectified** EMG **(µV)**

	AD		PD		BB		TB		FCR		ECR	
	S	M	S	M	S	M	S	M	S	M	S	M
Mean	370	337	161	186	178	175	274	280	248	255	216	224
SD	48.6	65.7	52.3	54.3	55.9	53.9	38.0	49.9	69.5	81.1	34.1	35.2
CV	0.16	0.20	0.30	0.26	0.31	0.29	0.14	0.18	0.31	0.31	0.16	0.17

No significant differences were found between scored and missed shots for integrated EMG, although misses tended to have slightly higher mean values (Table 5). It would be erroneous to cite greater total muscle activity as a reason for inaccurate shots, as an increase in both agonist and antagonist activity at each joint may produce a consistent net joint torque and, consequently, no change in endpoint kinematics. Greater variability was found for missed shots in all muscles, although no comparisons attained significance.

Table 5 **Integrated** EMG **(µV s)**

	AD		PD		BB		TB		FCR		ECR	
	S	M	S	M	S	M	S	M	S	M	S	M
Mean	95	93	37	55	45	46	95	104	44	50	99	101
SD	19.8	31.9	13.0	27.7	15.3	19.4	22.0	37.3	15.2	16.7	37.5	49.1
CV	0.23	0.34	0.36	0.38	0.35	0.42	0.27	0.32	0.40	0.33	0.41	0.43

CONCLUSION: Variability was apparent in both the temporal and frequency patterns of muscle activation and would seem to be an integral aspect of basketball shooting, and independent of outcome. There were, however, differences in activation between scores and misses. Missed shots were associated with greater variability than scored attempts in 80% of all comparisons. Although few significant differences were found, variability in muscle activgtion patterns may be associated with inaccuracy. Furthermore, inaccurate shots tended to be associated with greater variability about a different mean value, that is, a longer contraction duration, later activation, and greater median frequency.

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