CONTRIBUTION OF SELECTED MUSCLES TO BASKETBALL SHOOTING .

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INTRODUCTION

The elbow extensors have been suggested to be the major contributors to release speed in basketball shooting (Miller and Bartlett, 1993). However, this, and similar positions taken by other authors, have been made on the basis of kinematic information only, which may be misleading, especially in multijoint activities (Zajac and Gordon, 1989). As kinematics are largely influenced by the contractile history of the muscular system, an electromyographic analysis would be useful in assessing the veracity of this postulation, being the most objective method of assessing muscle activity.

The release speed and, thus, impulse generation requirements for shots of increasing distance are non-linear (Miller and Bartlett, 1996), and it may be expected that this necessitates non-linear changes in net muscle activity. Furthermore, identification of the muscles responsible for generating release speed may be used to develop sport-specific resistant training. It was the objective of this study to examine the activation patterns of muscles of the shooting arm for shots of varying distance.

METHODS

Twelve experienced male basketball players (Age; 22.0 ± 3.8 yrs.: Stature; 1.80 ± 0.08 m: Mass; 79.7 ± 9.7 kg) participated in the study. All had either represented the UWIC team in the last two years or were deemed by a qualified coach to be of similar standard. After a self-regulated warm-up, each subject was required to score five shots from each of three distances: (1) 2.74 m, (2) 4.57 m, (3) 6.40 m.

Six channels of electromyographic data were collected from the following muscles: anterior deltoid (AD), posterior deltoid (PD), biceps brachii (BB), triceps brachii (TB), flexor carpi radialis (FCR), extensor carpi radialis (ECR). Pre-gelled Ag/AgCl electrodes in a bipolar configuration with a contact area of 3.14 x 10^{-4} cm^2 were placed over the visual midpoint of the belly of the contacted muscle, parallel to the muscle fibres, and separated by approximately 0.03 m. The ground electrode was placed on an electrically unrelated site. The method outlined by Okamoto et al. (1987) was used to reduce skin resistance. Data were sampled at 1000 Hz by two MEGA ME3000P data loggers (Common Mode Rejection Ratio; > 130 dB), bandpass filtered (10-500 Hz) and downloaded to computer.

Contraction time (T_C) was measured from the full-wave rectified signal (time constant = 10 ms). Muscles were regarded as active when the signal exceeded 10% of its maximum value for the contraction, with relaxation defined as when the signal fell below the same value. Both average rectified emg (AREMG) and median frequency (MF) were obtained using a Fast Fourier Transform (FFT) of length which most closely corresponded to (but without exceeding) that of T_C. IEMG was computed as the product of AREMG and T_C.

A one-way analysis of variance (ANOVA) was used to determine whether differences existed for each parameter between shooting distances. The minimum a level for accepting statistical significance was set at 0.05 as, despite the associated risk of a Type I error, making a Type II error was regarded as the more undesirable. Fisher's Least Significant Difference test was used to determine the location of any statistically significant differences found.

RESULTS

Table 1. T_C, AREMG and MF data for all shooting distances.

	T_C (s)			AREMG (µV)			MF (Hz)		
	1	2	3	1	2	3	1	2	3
AD	0.40	0.44	0.33	239^{c}	305^{d}	$370^{c,d}$	61	58	61
PD	0.50	0.51	0.32	$79^{e,f}$	$123^{e,g}$	$161^{f,g}$	57^{q}	57^{r}	$49^{q,r}$
BB	0.38	0.37	0.29	$85^{h,i}$	$142^{h,j}$	$178^{i,j}$	61	60	51
TB	$0.29^{a,b}$	0.33^{a}	0.37^{b}	227^{k}	246'	$274^{k,l}$	$66^{s,t}$	75^{s}	73^{t}
FCR	0.28	0.33	0.28	204"	236"	248"	74	82	80
ECR	0.49	0.55	0.54	182^{0}	191^{p}	$216^{o,p}$	142	141	133

Values with like superscripts were significantly different from each other.
a,g,h,j,l,m,n,p,s,t,= $p <.05$; b,d,e,k,o,q,r = $p < .001$

Mean values for T_C, AREMG and MF are presented in Table 1. No significant differences were found between shooting distances for T_C, with the exception of TB, for which the contraction duration at distance 1 was significantly shorter than that at both 2 O, < .05) and 3 O, < .01). Different trends for the change in T_C with respect to shooting distance are evident in Figure 1. There was a reduction in T_C between distances 2 and 3 for four muscles (AD, BB, FCR, ECR), and in three muscles (AD, PD, BB) the duration at distance 3 was less than that at distance 1. The positive relationship between T_C and shooting distance for TB was inverted for its antagonist muscle (BB). An opposing agonist/antagonist trend was also found for AD and PD. The changes in FCR and ECR were consistent in their directions.

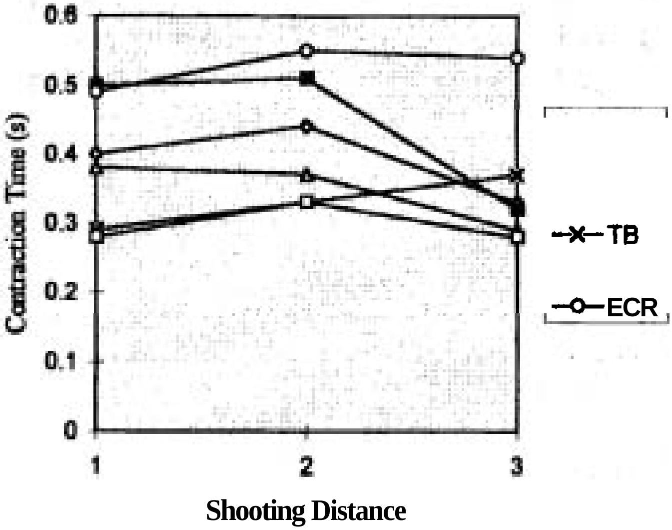

Figure 1. The relationship between TC shooting distance.

Table 1 and Figure 2 show AREMG to increase with shooting distance for all muscles. At the shoulder, this was nearly linear for both AD and PD, with the value at distance 3 being significantly greater than at both 1 ($p < .001$) and 2 ($p < .01$). At the elbow joint, the trend was somewhat different. The increase in AREMG for TB (agonist) was greater between distances 2 and 3, while that for BB (antagonist) was greater between 1 and 2 (all values significantly different from each other). The change in AREMG for the wrist agonist (FCR) was greater between distances 1 and 2, while that for its antagonist (ECR) was greater between 2 and 3.

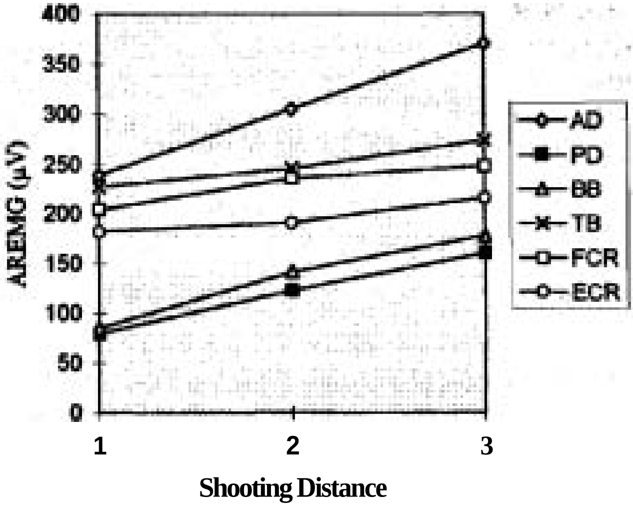

Figure 2. The relationship between AREMG and shooting distance.

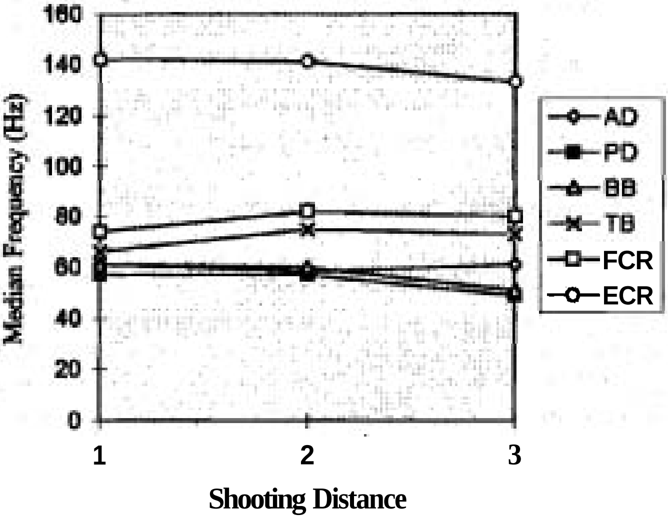

Figure 3. The relationship between MF and shooting distance.

Median frequency, higher values for which purportedly reflect increased muscle tension, remained relatively consistent for all shooting distances (Table 1, Figure 3). Significant differences were found for two muscles only, these being PD, for which values at distance 3 were significantly smaller than both 1 and 2 ($p < .01$), and TB for which values at distance 1 were significantly lower than both 2 and 3 ($p < .05$).

IEMG provides an indication of the total muscle activity, in this case over the duration of the contraction. Figure 4 shows that IEMG increased significantly ($p < .01$) between distances 1 and 3 for all muscles; however, the trend of that change across all distances was inconsistent. The increases for both TB and ECR were essentially linear, while for AD and PD, the IEMG at distance 2 was the peak value. The significant ($p < .05$) increases between distances 1 and 2 for BB and FCR were greater than those (non-significant) between 2 and 3.

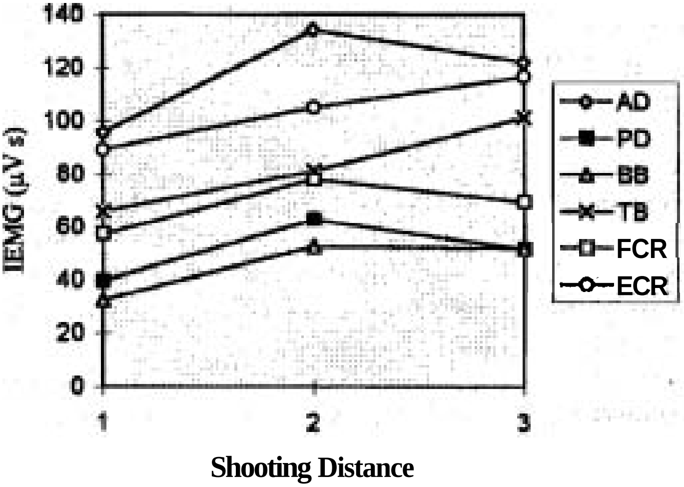

Figure 4. The relationship between IEMG and shooting distance.

DISCUSSION

The significant increase in T_c with shooting distance for TB, in conjunction with a concurrent increase in AREMG for the same muscle, results in an increased extensor torque-impulse at the elbow. While indicating a reduced opposing torque, the decrease in T_c for the antagonist muscle (BB) was offset by anincrease in AREMG which, when combined with T_c, resulted in a significantly increased IEMG between distances 1 and 2 (increased flexor torque-impulse), and a further, but non-significant, increase between 2 and 3. The increasing difference between the IEMGs of TB and BB with increased shooting distance may be tentatively regarded as evidence in support of both TB being a contributor to the greater release speed required as shooting distance increases, and the findings of Miller and Bartlett (1993), especially between distances 2 and 3. This does not, however, take into account contributions to the net joint toque-impulse by other elbow flexors. Given the activity of BB, it may be reasonable to assume that btachialis (and possibly brachioradialis)is also active, especially given the semi-prone positions of the radioulnar joint, which may offset the increased IEMG of TB. An alternative, and intuitively more appealing, interpretation is that BB is assisting AD as a shoulder flexor, and neither brachialis nor brachioradialis is active.

The trends in $\mathbf{T_c}$ for AD and PD were similar. The greater relative reduction in $\mathbf{T_c}$ for PD between distances 2 and 3, in conjunction with similar absolute increases in AREMG, resulted in similar IEMG trends. This may indicate a consistent net shoulder flexor torque at distances 2 and 3, and indirectly supports the findings of Miller and Bartlett (1993), who found little change in shoulder angular velocity at release with increasing shooting distance.

At the wrist, the greater increase in IEMG for the antagonist ECR between distances 2 and 3 compared to the agonist FCR provides support for the finding of Miller and Bartlett (1993) that the contribution of the wrist muscles to release speed at increased shooting distances tended to decrease. No support was in evidence for this contention, however, between distances 1 and 2.

The consistency of MF for all muscles suggests that the major contribution to changes in signal amplitude is made by recruitment of extra motor units, rather than an increase in firing frequency of recruited units. The decrease in MF between distances 2 and 3 for all muscles except AD was unexpected, as motor units recruited with increasing muscle tension have higher firing rates and, thus, median frequencies. This suggests that motor units recruited at distance 2 and 3 were of similar type to those recruited at distance 1. It may, however, be a function of the length and placement of the window from which this information was taken.

It is evident that, despite objective evidence of muscle activation, several difficulties exist in drawing firm conclusions with respect to net joint torques, due both the some muscles (e.g., BB) being biarticular, and the contribution to the net joint toque-impulse of muscles which were not analyzed. Furthermore, the complexity of muscular contraction renders interpretation of results of a dynamic activity problematic. Findings should thus be interpreted with due caution.

CONCLUSIONS

On the basis of the preceding analysis, the following conclusions were drawn:

(1) The increase in AREMG for all muscles indicates recruitment of a greater number of motor units for shots of increasing distance;

(2) The relative consistency of median frequency suggests that the fibre types of motor units recruited at distances 2 and 3 are similar to those recruited at distance 1;

(3) Increases in elbow extensor IEMG at all distances suggests that the required increase in ball release speed may be due to increase contributions from TB. Torque impulses from antagonist muscles must, however, be taken into account, as must contributions from muscles crossing other joints of the body;

(4) The increased difference in IEMG activity between ECR and FCR at distances 2 and 3 was unexpected, and suggests that the wrist flexors do not play a part in the required increase in ball release speed at distance 3;

(5) Due to the consistent increases in elbow extensor IEMG, it is recommended that players incorporate resistance exercises which simulate the elbow extension movement apparent in the shooting motion into their weight training.

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