ELECTROMYOGRAPHIC FACTORS CORRELATED WITH SOFTBALL BATTING PERFORMANCE

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INTRODUCTION: Specific muscle strength and coordination are required to produce a successful hit after a fast downswing in response to a high-velocity ball (Katsumata, 2007). Electromyographic (EMG) recording during the muscle contraction was a measurement to realize the motor strategy of sports. Several EMG researches about baseball or softball pitching have been documented in literature (Saito et al., 2001). However, there was very little research about softball batting surveyed in literature. Therefore, the purposes of this study were to investigate the muscle activities in upper extremities during softball batting and to analyze if any muscle activity is correlated with the ball exit velocity and bat head velocity.

METHOD: Seventeen female college softball batters participated in this study. Surface EMG signals on anterior deltoid, posterior deltoid, pectoralis major, biceps brachii and triceps brachii were measured bilaterally during softball batting. In this study, pushing arm was defined as the upper limb in the same side of the supporting leg while leading arm was defined as the upper limb in the same side of the leading leg. MA300 EMG system (Motion Lab Systems, Inc.) was used at a sampling rate of 1000 Hz. Maximum voluntary contraction (MVC) was measured for each muscle before collecting batting trials.
VICON 612 motion analysis system (Oxoford Metrics Limited.) with six digital cameras was used. The sampling rate was 250 Hz. In softball batting trials, the trajectories of the softball wrapping with reflective material and the reflective marker on bat head were measured and EMG signals in upper limbs were simultaneously collected. A softball was placed on a stationary framework. The height of the framework could be adjusted to match the most proper batting position for each subject, about the level of anterior superior iliac spine. Three bats were used, consisted of light (22 oz), regular (26 oz) and heavy (30 oz) bats. Six successful batting trials in which there was proper bat contact were selected for each bat. The maximum ball exit velocity (the batted ball velocity) and the bat head velocity were calculated. The EMG signals in acceleration phase of softball batting were computed as root mean square values and normalized by MVC for each muscle. The average of six trials was calculated for each subject. Pearson correlation coefficient was analyzed to see if any EMG parameter was correlated with softball performance (n=17).

RESULTS: The ball exit velocity and bat head velocity were shown in Table 1. The correlation coefficients with significance ($p<0.05$) were shown in Table 2. Ball exit velocity was correlated with bat head velocity. The heavier bat had the trend of stronger correlation between ball velocity and bat velocity.
With the use of a light bat (22 oz), posterior deltoid in leading limb ($r=0.588$) and triceps brachii in pushing limb ($r=0.495$) were correlated with bat head velocity. With the use of a regular bat (26 oz), posterior deltoid in leading limb was correlated with ball exit velocity ($r=0.551$), posterior deltoid in pushing limb ($r=0.520$) and biceps brachii in leading limb ($r=0.484$). Triceps brachii in pushing limb was correlated with anterior deltoid ($r=0.643$) and posterior deltoid in pushing limb ($r=0.622$). With the use of a heavy bat (30 oz), posterior deltoid in pushing limb was correlated with biceps brachii in leading limb ($r=0.811$), anterior deltoid in pushing limb ($r=0.559$) and posterior deltoid in leading limb ($r=0.513$).

Table 1. The ball exit velocity and bat head velocity (m/s)

Bat weight	Ball exit velocity	Bat head velocity
22 oz	20.54±1.81	25.02±2.21
26 oz	24.72±1.48	24.62±2.27
30 oz	20.64±2.58	24.23±2.50

Table 2. Correlation Coefficients between ball exit velocity, bat head velocity and EMG parameters (L: leading arm; P: pushing arm)

Bat weight	Variable 1	Variable 2	r	p
22 oz	Ball exit velocity	Bat head velocity	0.652	0.005
	Bat head velocity	Posterior deltoid (L)	0.588	0.013
	Bat head velocity	Triceps brachii (P)	0.495	0.043
26 oz	Ball exit velocity	Bat head velocity	0.804	0.001
	Anterior deltoid (P)	Tricpes brachii (P)	0.643	0.005
	Posterior deltoid (P)	Triceps brachii (P)	0.622	0.008
	Ball exit velocity	Posterior deltoid (L)	0.551	0.022
	Posterior deltoid (L)	Posterior deltoid (P)	0.520	0.032
	Posterior deltoid (P)	Anterior deltoid (P)	0.515	0.034
	Posterior deltoid (L)	Biceps brachii (L)	0.484	0.049
30 oz	Ball exit velocity	Bat head velocity	0.832	0.000
	Posterior deltoid (P)	Biceps brachii (L)	0.811	0.000
	Posterior deltoid (P)	Anterior deltoid (P)	0.559	0.020
	Posterior deltoid (P)	Posterior deltoid (L)	0.513	0.035
	Posterior deltoid (L)	Anterior deltoid (L)	-0.574	0.016

DISCUSSION: Bat head velocity was highly correlated with ball exit velocity (all bats), implying that a fast bat head velocity is useful for performing a high ball exit speed in softball batting. Also, the posterior deltoid in leading arm and triceps brachii in pushing arm were correlated with bat velocity or ball velocity. The importance of these two muscles in softball batting might be obviously revealed. The batting skills might be improved if the motor strategy of upper extremity could be modified as highlighting the activations of posterior deltoid in leading arm and triceps brachii in pushing arm.

CONCLUSION: The findings of this study demonstrated the specific EMG in the muscles of leading arm and pushing arm, which showed significant correlation with bat velocity and ball velocity. The correlation of muscle activation with bat velocity suggests that specific muscle conditioning programmes may improve batting performance.

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