ELECTROMYOGRAPHIC ANALYSIS OF THE DISCUS STANDING THROW

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The purpose of this study was to compare the muscular activation in different discus weights and investigate the sequences and the patterns of the muscular function of the standing throws with discus. The surface EMGs of thirteen muscle groups were measured. The forearm flexor, triceps brachii, posterior deltoid and middle deltoid were highly activated muscle groups in the standing throws. The forearm flexor exerted the highest activation among thirteen muscle groups. The trapezius, pectoralis major, forearm muscle groups, biceps brachium, and anterior deltoid reached the peak EMG activities just before the discus was released. The posterior deltoid, middle deltoid, lower trapezius, and middle trapezius mainly supported the arm and the discus in the early part of the standing throws.

KEY WORDS: electromyography, throw, discus

INTRODUCTION: A throwing arm plays a crucial role in throws. Many researchers have studied the muscular activation and function of the throwing arm by Electromyography (EMG). However, most of the electromyographic studies of the upper extremities of throwing sports were concerning the baseball pitching (Gowan, et. al., 1987; Jobe, et. al., 1983; Jobe, et. al., 1984; Moynes, et. al., 1986; Sisto, et. al., 1987). Comparing to baseball (0.145 kg.) pitching, discus throwing is a heavy-weighted throwing sport (2.00 kg. for Men). A few researchers study the EMG of heavy-weighted throwing events. So, we selected the heavy-weighted discus-throwing event as our study subject. The weight of a discus for Men is 2.00 kg. We also asked the subjects to throw lighter discuses, which were 1.75 kg. and 1.00 kg. in weight. In addition, the standing throw with a discus is a basic training movement because it can improve the thrusting technique on the discus throwing. The purpose of this study was to compare the muscular activation in different discus weights, and investigate the sequences and the patterns of the muscular function of the standing throws with a discus.

METHODS: Seven discus throwers (age of 20 ± 3 years; height of 178 ± 9 cm; weight of 100 ± 24 kg.) served as subjects to perform the standing throws with three weights of the discus (1.00, 1.75 and 2.00 kg.). A definition of the standing throw: the athlete stood with the back toward the direction of throw, stepped back with the left foot, and then rotated the hip following by the chest and throwing arm. Each subject performed at least two throws without fouls. The best trail with the farthest distance for each subject was analyzed. Two Redlake high-speed cameras (sampling rate: 125 Hz; Motion Scope, San Diego, CA) and one DasyLab system (sampling rate: 1250 Hz; National Instruments, Austin, TX.) were synchronized to collect the data. The surface EMG of thirteen muscle groups, which were upper trapezius, middle trapezius, lower trapezius, anterior deltoid, middle deltoid, posterior deltoid, clavicular pectoralis major, sternal pectoralis major, biceps brachium, triceps brachii, forearm extensor, forearm flexor and serratus anterior, were recorded during the throwing motion (Cram, et. al., 1998). Raw EMG signals were band-pass filtered (20-400 Hz), full wave rectified, and passed through a linear envelope at 10 Hz for final interpretation. The mean value of integrated EMG signals ($IEMG/t_o$-t_r) from the onset (t_o) of thrust to the discus release (t_r) of the trials were then standardized by the maximal signal, which was highest EMG value (EMG_{max}) in the curve passed through a linear envelope among the three weights, for each muscle to indicate relative activation levels (% max) (Winter, 1990). The nonparametric statistical test of Friedman two-way analysis of variance by ranks was conducted for the standardized IEMG of each muscle ($p = 0.05$). The phase of the standing throw with discus was from the start of the trunk rotating toward throwing direction to the release of the discus.

RESULTS AND DISCUSSION: Average distances of performances and the throwing time of standing throws with the 1.00, 1.75 and 2.00 kg. discus are shown in Table 1 and Table 2 respectively. Generally, throwing a heavier discus got a shorter throwing distance. There were no significant differences among those discuses in the throwing time.

Table 1 Average Distances of subjects.

	Distance of 1.00 kg. (m)	Distance of 1.75 kg. (m)	Distance of 2.00 kg. (m)
MEAN	48.77	38.39	35.49
SD	5.28	5.99	5.16

Table 2 Average throwing time of subjects.

	Throwing time of 1.00 kg. (sec)	Throwing time of 1.75 kg. (sec)	Throwing time of 2.00 kg. (sec)
MEAN	0.59	0.60	0.59
SD	0.09	0.07	0.06

Figure 1 shows the activation levels of the thirteen muscles. There were no statistical significances between those weights in the standardized IEMG of muscles. However, there was a trend that the activation levels of forearm flexor and extensor, biceps brachium, anterior deltoid, and clavicular pectoralis major increased to the heavier discus. Those muscles that the standardized IEMG was up to 30% in three weights were the forearm flexor, triceps brachii, posterior deltoid, middle deltoid, middle trapezius, and upper trapezius. They demonstrated stronger activities than those of the other muscle groups in the standing throws. The highest standardized IEMG was found on forearm flexor (42.4%) when subjects threw 2.00 kg. discus. The second one was also found on forearm flexor (39.7%) when subjects threw 1.75 kg. discus. It indicated that the activation of the forearm flexor played a crucial part in discus throws.

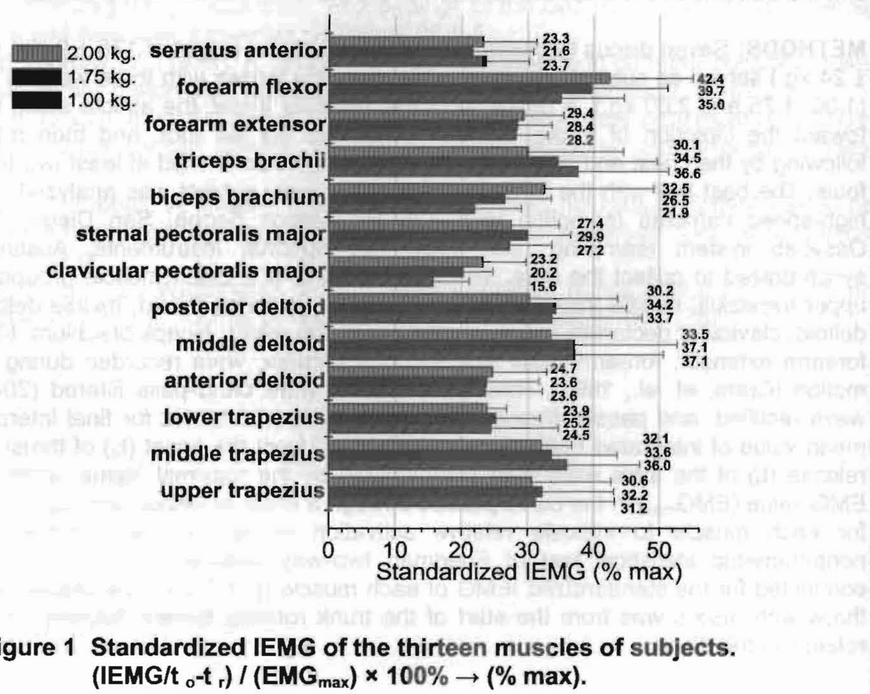

Figure 1 Standardized IEMG of the thirteen muscles of subjects.
$(IEMG/t_o-t_r) / (EMG_{max}) \times 100\% \rightarrow$ (% max).

Figure 2 shows the time to peak EMG of thirteen muscles of seven subjects. There was only a statistical significance found in the time to peak EMG of the forearm flexor between the three weights of the discus. Most muscle groups reached the peak EMG after 60% of the standardized time. The subjects exerted much muscular activation in the latter part of the standing throws. The trapezius, pectoralis major, forearm muscle groups, biceps brachium, and anterior deltoid reached the peak EMG just by the discus release. The sequences to the peak EMG of muscles were a little different in three weights of discus throws. Chowdhary and Challis (1999) pointed that an optimal throw is performed when the onset of the proximal muscle precedes that of the distal one. However, in this study, it was hard to clarify the proximal to distal segmental sequence because the time to peak EMG sequences varied in three weights of the discus. Moreover, more muscles were activated and the interactions between segments were more complicated in the discus throws.

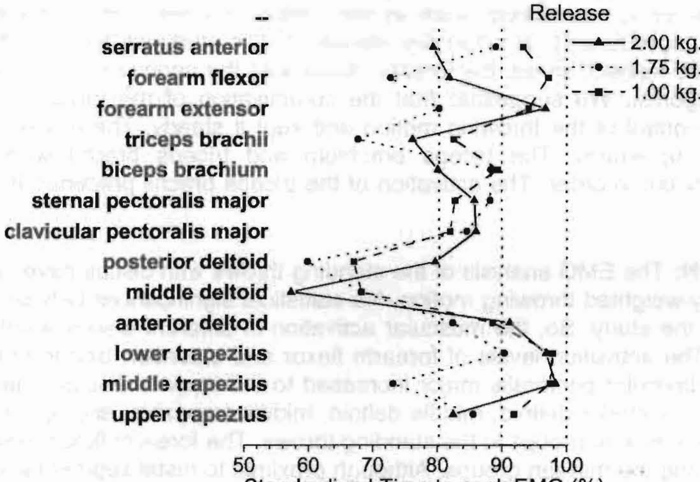

Figure 2 Time to peak EMG of thirteen muscles of the subjects (mean). Time was normalized to standing throw duration (100%).

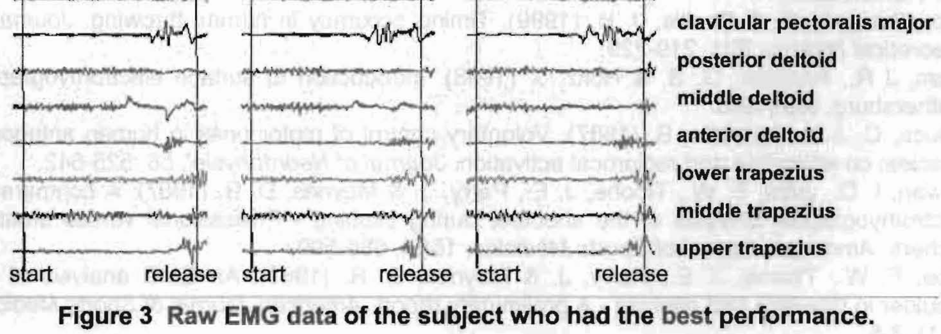

Figure 3 Raw EMG data of the subject who had the best performance.

Figure 3 shows the raw EMG data of the subject who threw the farthest distance. The activation patterns of three weights of discus throws were generally similar. There was activation in the early part of the standing throws observed in the posterior deltoid, middle deltoid, lower trapezius, and middle trapezius. We analyzed this phenomenon with the motion analysis system and suggested that the main function of those muscles was supporting the arm and the discus. However, the lower trapezius, and middle trapezius as well as upper trapezius reached their peak EMGs in the latter part of the standing throws just prior to the release. At that moment they were activated for accelerating the discus. The function of the anterior deltoid was obviously different from the posterior and middle deltoid. It was activated in the latter part of standing throws for accelerating the discus. The clavicular pectoralis major, sternal pectoralis major, biceps brachium, forearm extensor, forearm flexor, and serratus anterior were also activated in the latter part of standing throws for accelerating the discus. Deluca and Mambrito (1987) indicated that the antagonist tends to have co-activation in some circumstances such as the control of a fast motion, the motion requiring stability, and unpredictable or unfamiliar motion. In this study we found that there was co-activation in the forearm where the forearm flexor was the agonist and the forearm extensor was the antagonist. We suggested that the co-activation of the forearm extensor mainly provided the control of the throwing motion and kept it steady. There was no co-activation found in the upperarm. The biceps brachium and triceps brachii were not activated simultaneously but in order. The activation of the triceps brachii preceded that of the biceps brachium.

CONCLUSION: The EMG analysis of the standing throws with discus gave us many insights into the heavy-weighted throwing motion. No statistical significances between those weights was found in the study. So, the muscular activation in different discus weights of the study was similar. The activation levels of forearm flexor and extensor, biceps brachium, anterior deltoid, and clavicular pectoralis major increased to the heavier discus. The forearm flexor, triceps brachii, posterior deltoid, middle deltoid, middle trapezius, and upper trapezius were highly activated muscle groups in the standing throws. The forearm flexor exerted the highest activation among the thirteen groups. Although proximal to distal segmental sequences were hard to clarify in the study, the patterns of the muscular function were evident. The trapezius, pectoralis major, forearm muscle groups, biceps brachium, and anterior deltoid reached the peak EMG activities just before the discus was released. The posterior deltoid, middle deltoid, lower trapezius, and middle trapezius mainly supported the arm and the discus in the early part of the standing throws. The anterior deltoid, clavicular pectoralis major, sternal pectoralis major, biceps brachium, forearm extensor, forearm flexor, and serratus anterior were activated in the latter part of the standing throws for accelerating the discus. Besides, an interesting observation was found in the forearm. There was co-activation between the forearm extensor and flexor. The forearm extensor had the co-activation mainly to provide the control of the throwing motion and kept it steady.

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