ELECTROMYOGRAPHIC ANALYSIS IN ABDOMINAL MUSLCES DURING CURL-UP EXERCISES

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INTRODUCTION: Trunk muscle strength is necessary to maintain the core stability. Several abdominal machine exercises have been investigated through electromyographic (EMG) analysis. Escamilla, et al. (2008) studied numerous abdominal exercises and found that Ab Slide and Torso Track were the most effective exercises in activating abdominal muscles with the relative high EMG activities during abdominal exercise. High internal oblique activities and low rectus abdominis activities in bridging stabilization exercise were also found in EMG analysis (Stevens et al., 2006). One of the most common and convenient ways to strengthen abdominal muscle is the sit-up or curl exercise, which could even be performed at home in healthy populations. However, little research has been conducted to study the curl-up exercise. Therefore, the purpose of this study was to investigate the relative EMG activation levels in rectus abdominis and external oblique during the curl-up exercise. The abdominal strengthening technique with higher EMG activities would be revealed in this study.

METHOD: Twelve healthy male subjects (age 21.0±0.7 years, weight 65.5±7.7 kg, height 175.3±5.0 cm, body mass index 21.1±1.8 kg/m^2) participated in this study. The subjects had not participated in regular strengthening programs. Subjects with surgery history in trunk or lower extremity or any other neuromuscular deficit were excluded from this study.
EMG signals in rectus abdominis and external oblique were measured bilaterally. Biopac EMG system was used in this study. Skin was cleaned with alcohol wrap and four surface EMG electrodes were placed on the abdomen. EMG signals in maximum voluntary contraction (MVC) were first measured for each muscle. Subjects were then asked to perform curl-up exercises with both arms crossed in front of the chest in static or dynamic testing conditions. Subjects had to maintain position at 30 or 60 degrees of trunk flexion for 10 sec in static isometric test. In dynamic test, subjects consecutively performed ten curl-up movements from supine lying to 30, 60, or 90 degrees of trunk flexion and then reversed at the frequency of 40 cycles/min. The feet of the lower extremities were placed on the ground with knee bent. A specific designed goniometer was used to assure the trunk position at a correct angle. There was a two-min resting interval between each testing condition. The testing sequence was random for each subject. Root mean square values of EMG signals were computed and the average EMG data in left and right sides were calculated. EMG data were normalized as a percentage of MVC. One-way ANOVA with repeated measures was performed to compare the EMG activation between different testing conditions (SPSS).

RESULTS: EMG activations during dynamic and static testing conditions were shown in Table 1. For rectus abdominis, dynamic curl-up movements at 0-30, 0-60 and 0-90 degrees in upward phase (43.9%MVC in average) had significantly greater EMG activities than downward phase (30.4%MVC in average) ($p<0.05$). Isometric contraction at 60 degrees (19.9%MVC) significantly had the lowest EMG level in all testing conditions ($p<0.05$).
For external oblique, dynamic curl-up movements at 0-30,0-60 and 0-90 degrees in upward phase and isometric condition at 30 degrees (59.5%MVC in average) had significantly greater EMG activities than dynamic curl-up movement at 0-30,0-60 and 0-90 degrees in downward phase and isometric condition at 60 degrees (40.1%MVC in average) ($p<0.05$). And the dynamic curl-up movement at 0-60 degrees in upward phase (61.3%MVC) had significantly greater EMG levels than dynamic curl-up exercises at 0-30 degrees in upward phase (55.8%MVC).

Table 1. EMG activities (%MVC) in dynamic and static testing conditions

	Dynamic						Static	
Angles	0 - 30		0 - 60		0 - 90		30	60
Phase	Up	Down	Up	Down	Up	Down	Iso	Iso
Rectus Abdominis*	44.1[a] (15.3)	30.2 (13.5)	46.1[a] (16.7)	29.4 (10.0)	44.9[a] (18.0)	31.6 (13.5)	40.6 (24.4)	19.9[c] (13.0)
External Oblique*	55.8[abd] (13.2)	39.0 (14.9)	61.3[ab] (17.2)	38.7 (17.2)	60.9[b] (14.0)	42.5 (14.9)	60.0[b] (21.0)	40.2 (16.9)

Up=upward; Down=downward; Iso=isometric. *p<0.05, ANOVA with repeated measures. Multiple comparison (p<.05): a) greater than downward phases at 0-30°, 0-60°, and 0-90°; b) greater than Isometric contraction at 60°; c) lesser than all other conditions; d) lesser than upward phase at 0-60°.

DISCUSSION: In addition to machine exercise, this study attempted to use the EMG activation level during curl-up exercise to recognize the optimal strengthening strategy of abdominal muscles. Curl-up exercise in upward phase would be beneficial in increasing muscle load and more recruitment, while statically maintaining posture at 60 degrees of trunk flexion had minimal muscle firing. The findings of this study would be helpful in the implication for muscle strengthening, physical rehabilitation and athletic training.

CONCLUSION: This study identified the most effective method to facilitate abdominal muscle contraction based on an EMG analysis. Curl-up exercise from supine lying to 60 degrees of trunk flexion could produce the highest EMG activities both in rectus abdominis and external oblique, ranging from 46%MVC to 61%MVC.

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