ABDOMINAL MUSCLE ACTIVATION IN TWO TRUNK-CURL TESTS

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INTRODUCTION

Health-related fitness test batteries commonly evaluate muscular endurance with timed sit-up or curl-up tests. Recently, several trunk-curl tests of abdominal endurance have been developed (Diener, Golding, & Deiner, 1995; Knudson & Johnston, 1995; Millard-Stafford, Snow, & Sparling, 1994; Robertson & Magnusdottir, 1987; Toshikazu et al., 1996). Trunk-curl tests are hypothesized to be safer and more valid tests of abdominal endurance than traditional bent-knee sit-ups (Alexander, 1985; Jette, Sidney, & Cicutti, 1984; Knudson, 1996a; Macfarlane, 1993; Norris, 1993; Robertson, Humphreys, & Brodowicz, 1994; Robertson & Magnusdottir, 1987). Despite an abundance of EMG studies comparing trunk-curls with the bent-knee sit-up, few studies have compared abdominal activation in variations of trunk-curls (Knudson, 1996a).

The purpose of this study was to compare the activation of abdominal muscles in two variations of trunk-curls used in fitness testing, the bench trunk-curl (Knudson & Johnston, 1995) and the modified trunk-curl currently used in the Fitnessgram program (CIAR, 1992). The bench trunk-curl (BTC) movement is hypothesized to have safety and technique advantages over modified trunk-curl (MTC) (Knudson, 1996a). The BTC position (Figure 1) may have greater posterior pelvic tilt, greater shortening of the hip flexors, and decreased shear forces in the lumbar spine (Johnson, & Reid, 1991). The decreased stabilization of the BTC (moving the weight of the legs), as compared to the MTC, could result in increased external oblique (EO) activation to coordinate and control the curl-up (Gilleard & Brown, 1994; Miller & Medeiros, 1987; Norris, 1993). The BTC requires about 4 more degrees of trunk flexion (26.2 versus 22.4 degrees) and creates a 4% greater gravitational torque than the MTC (Knudson, 1996b). These technique advantages were hypothesized to result in greater abdominal activation in the BTC compared to the MTC.

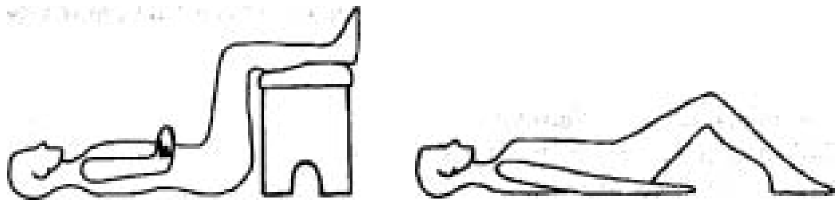

Figure 1. Starting positions of the MTC and the BTC

METHODS

Twenty-three college students (12 female and 11 female) volunteered to participate in the study and gave informed consent. Subjects were between 19 and 24 years of age with mean (+/- SD) height and mass of 1.70 +/- 0.15 m and 69.7 +/- 15.1 kg.

Surface electromyography was used to measure the activity of the rectus abdominis (RA) and the external oblique (EO) muscles during the two trunk-curl exercises. Silver/silver-chloride surface electrodes (10 mm) were placed on the right upper rectus abdominis and the left external oblique. A ground electrode was placed on the anterior superior iliac spine. Raw EMG signals were amplified by a Noraxon Myosystem 2000. The amplifier provided a gain of 10,000, CMRR of 115 db, input impedance of 10 megaohms, and a bandpass of 16 to 500 Hz. A Penny & Giles M180 electrogoniometer was attached to the right iliac crest and the rib cage to document the initiation of each trunk-curl. EMG and goniometer signals were wire transmitted and 12 bit A/D converted at 1000 Hz and saved.

Subjects were familiarized with the two trunk-curl tests and were instructed to smoothly perform the movements to a cadence (20 repetitions per minute) maintained by a metronome (Godfrey, Kindig, & Windell, 1977; Noble, 1981). The order of the BTC and the MTC was randomized and at least one minute of rest was given between tests. EMG and goniometer data were collected for six repetitions arbitrarily chosen within the first 20 repetitions (one minute). Two maximal isometric trunk flexions (flexion and flexion with axial rotation) against manual resistance (MVC's) were performed following the trunk-curl tests.

Raw EMG data were full-wave rectified and the initiation of each trunk-curl was established by the goniometer signal. The mean rectified EMG signals of the RA and EO was calculated over the first 500 ms after the initiation of trunk flexion. Mean EMG voltages of each muscle for each subject were averaged across the six repetitions and expressed as a percentage of MVC. Two dependent t tests with a Bonferroni correction were used to examine the effect of trunk-curl test on the activation of the RA and EO. Statistical significance for the study was set at $p < 0.05$.

RESULTS AND DISCUSSION

Dependent t-tests demonstrated that the rectus abdominis (RA) activation in the bench trunk-curl (BTC) and the modified trunk-curl (MTC) were not significantly different ($t = 1.12$, $p = 0.27$). There was also no significant difference in external oblique (EO) activation between the two trunk-curl tests ($t = 1.13$, $p = 0.27$) The mean normalized activation of the RA and EO in the two trunk-curl tests are presented in Table 1.

Muscle	BTC	MCU
RA	14.2 (5.2)	13.5 (4.6)
EO	12.0 (4.4)	10.9 (5.1)

Data in percent of maximal voluntary contraction (MVC).

Table 1. Mean (± SD) Normalized EMG of the Rectus Abdominis (RA) and External Oblique (EO) for the Bench Trunk-Curl (BTC) and the Modified Trunk-Curl (MTC)

Several aspects of the results were consistent with previous EMG studies of abdominal muscles. Results supported a recent study finding similar EMG activity of the abdominal muscles in several curl-up variations (Behm et. al., 1997). Mean activation of the RA and EO in the initial concentric phases of these trunk-curls were between 10.9 and 14.2% of MVC. This was slightly less than the 30 to 40% activation reported in six variations of abdominal exercises studied by Ekholm, Arborelius, & Fahlcrantz (1979). These results suggest that trunk-curl movements without external loads provide a small resistance to the abdominal muscles.

Within subjects the mean rectified EMG across the six repetitions of each curl-up were quite consistent. However, like previous studies of abdominal tests and exercises, between subject responses of abdominal muscles to the various trunk-curls and maximal voluntary contractions showed larger variability (Ekholm, Arborelius, & Fahlcrantz, 1979; Gilleard

& Brown, 1994; Sarti et. al., 1996). 'Seventy percent of the subjects utilized greater EO activity in the BTC than in the MTC and sixty-one percent of the subjects used greater RA activity in the BTC than in the MTC. Previous abdominal muscle training and skill in the movements have recently been found to be factors contributing to the large between subject variability of EMG responses of abdominal muscles (Sarti et. al., 1996). Future studies factor in level of training and expertise in examining differences in abdominal muscle activation across exercise techniques.

Between subject variability was also observed in the EMG responses to the isometric MVC's. Maximal EMG voltage of the EO was measured in some subjects in the symmetric trunk flexion, not the trunk flexion combined with axial rotation. This variability has also been observed in a previous study (Noble, 1981). Noble (1981) found that the EMG of the EO was more sensitive to changes in exercise technique than the RA, and surprisingly EO activity was not always greater in movements including a twist.

CONCLUSIONS

It was hypothesized that the body positioning advantages of the BTC would create significantly greater RA and EO activation than the MTC. The data did not support this hypothesis, and it was concluded that for these subjects there was no significant difference in mean normalized EMG of the RA and EO between the BTC and the MTC. The lack of statistical significance was not likely a type II error because the statistical power of this experiment was greater than 0.90. The lack of a statistically significant difference may be due to the large between subject variability of abdominal muscle activation in normal subjects.

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