SIT-UPS REVISITED WITH INTRAMUSCULAR EMG

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INTRODUCTION

Abdominal muscles serve a multitude of functions in controlling posture and movement, providing stabilization of the spine and participating in breathing. Exercises for the abdominal muscles are an integral part of most training programs in sports and rehabilitation. A multitude of practical recommendations exist on how to best perform this type of exercise to reach a specific effect. In recent years, special attention has been paid to training of the innermost abdominal muscle, the Transversus Abdominis (TrA), which has been ascribed a role in trunk stabilization and posture control [1,2], but whose mechanical contribution to trunk movements still is uncertain. The purpose here was to further elucidate the multifunctional role of abdominal muscles, particularly the TrA, by investigating the effects of (I) systematic breathing interventions, and (II) load and direction modifications on the involvement of all four abdominal muscles during trunk curl exercises.

METHODS

Ten healthy habitually active young females performed trunk curls from a supine position with bent knees. The movement speed was set by a metronome and the upward and downward phases each lasted approximately 2 s. The experiments were carried out in 2 blocks of 5 variants each: *Block I*, sagittal trunk curls with 1) spontaneous breathing 2) inhalation during the upward and downward phases 3) exhalation during the upward and downward phases 4) breath-holding on a maximal inhalation level, and 5) breath-holding on a maximal exhalation level. *Block II:* 1) sagittal trunk curl with straight arms in front of the body, 2) ditto with arms crossed over the chest, 3) ditto with hands behind the neck, 4) trunk curl with left twist, and 5) trunk curl with right twist. In Block I, air flow was measured with a respiratory flow-meter. Kinematics was recorded with a position transducer. Intramuscular electromyography (EMG) was recorded via bipolar fine-wire electrodes placed under the guidance of ultrasound in the Transversus Abdominis (TrA), Obliquus Internus (OI), Obliquus Externus (OE), and Rectus Abdominis (RA) muscles on the right side. Root mean square EMG was calculated for 1 s intervals in the middle of the upward and downward phases and expressed as a percentage of the EMG obtained in an isometric maximal voluntary sagittal trunk curl in a supine position. Repeated-measures ANOVA and pre-planned pair-wise comparisons were used ($P<0.05$).

RESULTS

The overall range of relative EMG-levels was 6-72%. The activation of TrA was lower than that of the other muscles (6-36% versus 14-72%). All muscles showed higher activation during the upward than the downward phase (ranges: 13-72% versus 6-56%). *In Block I:* A significant effect of an intervention was present only for the breath-holding in exhalation situation, which showed higher EMG-values than the spontaneous breathing situation for OE and RA both in the upward and downward phases. The breath-holding in exhalation also caused higher activation than the corresponding inhalation situation for OI, OE and RA. Comparisons between trunk curls with ongoing breathing showed higher EMG levels with exhalation than inhalation for OI and OE. No significant differences between situations were seen for TrA. *In Block II:* Changing the arm position cranially increased the EMG of all muscles in both phases. EMG on the right side was increased in the upward phase with right twist for OI and with left twist for OE. TrA and RA activation did not change significantly with twist in either direction.

DISCUSSION

The level of activation of superficial abdominal muscles, OE and RA, can be increased by holding the breath in maximal exhalation during trunk curls. A possible reason for that could be that an extreme exhalation decreases the lever arm for these primary trunk flexor muscles and thus a higher level of activation is needed to carry out the movement. The lack of significant effects of breathing interventions on the deep abdominal muscles, OI and TrA, was somewhat unexpected, considering their potential role in control of breathing [3]. Possibly, the generally low activation of the transversus abdominis, and presumably a concomitant low intra-abdominal pressure [4], would be mechanically beneficial for the execution of the trunk curl. As expected, the modification of arm position, and thereby load, caused a general increase in activation of the primary abdominal flexor muscles. Interestingly, there was an increase also in TrA activation, which could be interpreted as related to a concomitant increase in the need for spine stabilization. The asymmetric activation of the oblique abdominal muscles is in accordance with their main fibre directions. A tendency towards a similar pattern of activation in TrA and OI is in line with our earlier observations during trunk twisting in a standing position [4] and suggests a mechanical role for TrA in ipsilateral trunk rotation. From a practical viewpoint, the data presented can provide guidelines for specific trunk muscle training and for explaining effects thereof.

REFERENCES

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