TRUNK MUSCLE ACTIVATION DURING Dynamic WEIGHT-TRAINING Exercises and ISOmetric Instability Activities

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Abstract. Hamlyn, N., D.G. Behm, and W.B. Young. Trunk muscle activation during dynamic weight-training exercises and isometric instability activities. J. Strength Cond. Res. 23(6):1106-1112. 2009.—The purpose of this study was to examine the extent of activation in various trunk muscles during dynamic weight-training and isometric instability exercises. Sixteen subjects performed squats and deadlifts with 80% 1 repetition maximum (1RM) and performed single-leg squats on 2 unstable calisthenic-type exercises (supersam and sidestep). Electromyographic (EMG) activity was measured from the lower abdominals (LA), external obliques (EO), upper lumbar erector spinae (ULES), and lumbar-sacral erector spinae (LLES) muscle groups. Results indicated that the LLES EMG activity during the 80% 1RM squat significantly exceeded 80% 1RM deadlift. The LA, EO, and ULES EMG activity of the 80% 1RM squat also exceeded the body weight, deadlift, superman, and sidestep by 56, 56, 56, 53, and 31%, respectively. The 80% 1RM deadlift ULES EMG activity significantly exceeded all of the other tests, with the superman and sidestep by 86, 68, and 56%, respectively. Consequently, the EMG activity of all muscle groups significantly increased when compared with a stable squat movement. In addition, Behm et al. (4) have subjects perform various trunk-stabilizing exercises with unstable and stable (Swiss ball) conditions. Results indicated that the abdominal stabilizers, LLES, and ULES exhibited significantly greater activity with the unstable conditions. The 2 most effective exercises for the trunk muscles were Swiss ball and with previous experience with weight-training and Swiss Ball exercises. An important finding was that core stability muscle activation was completed a physiological or functional core stability questionnaires were used to identify significant health problems. Exclusion criteria included any individuals with known acute or chronic back pain. Each subject was required to read and sign a consent form prior to participating in the study. The University of British Columbia Ethics Committee approved the study.

Measurements
Surface EMG electrodes were used to measure signals from the lower abdominals (LA), external obliques (EO), and lumbar-sacral erector spinae (LLES) muscle groups. EMG activity was measured in millivolts from the electrodes, the placement area was shaved, abraded, and cleaned with alcohol to improve the conductivity of the electrodes. The electrodes were placed on the skin referred to as the LLES muscles (2, 4, 26). Electromyograms (Kendall Mini-trace 100 series, Chippewa, MN) were used to record EMG activity. Reference electrodes were placed for the LLES muscles and 6 cm lateral to the L1L2 spinous processes for the lumbar muscle groups. Deep within the lumbar muscle groups, electrodes were placed on either side during the 2-second periods analyzed during the instability exercises. Participants were instructed not to perform any instability at the beginning time of the exercise and fatigue at the end. Although only normally should not directly compare dynamic contractions to isometric contractions, the trunk muscles would have been contracted isometrically during the squats and the deadlift exercises, as well as during the unstable isometric activities. Exercise Protocol
After an adequate warm-up (10 repetitions that did not exceed 80% of 1RM) and a resistance was estimated that would force the participant to fail to complete more than 8 repetitions. Participants performed two sets of 10 repetitions. The National Strength and Conditioning Association tables (18). From the estimation, 45% and 80% 1RM were calculated for both the critical load. Consequently, electrons were either placed on the area referred to as the LLES muscles (2, 4, 26). Electromyograms (Kendall Mini-trace 100 series, Chippewa, MN) were used to record EMG activity. Reference electrodes were placed for the LLES muscles and 6 cm lateral to the L1L2 spinous processes for the lumbar muscle groups. Deep within the lumbar muscle groups, electrodes were placed on either side during the 2-second periods analyzed during the instability exercises. Participants were instructed not to perform any instability at the beginning time of the exercise and fatigue at the end. Although only normally should not directly compare dynamic contractions to isometric contractions, the trunk muscles would have been contracted isometrically during the squats and the deadlift exercises, as well as during the unstable isometric activities.
The 80% 1RM squat exercise exhibited significantly (p = 0.0096) greater LSLES EMG activity than all other exercises (Figure 1). Squat LSLES EMG activity at 80% 1RM significantly (p = 0.0027) exceeded the performance of dynamic, weightlifting exercises and isometric instability exercises. Bars depict the mean combined data of the individual exercises. Asterisks indicate that the exercise was significantly different from all other exercises.

In addition, the 80% 1RM deadlift LSLES EMG activity also exceeded the body weight squat, deadlift, superman, and sideway exercises by 56.7, 13.5, 26.3, and 64.2% respectively. There were no significant LSLES EMG differences between the body weight squat, deadlift, superman, and sideway exercises.

External Obliques and Lower Abdominals

From the 4 exercises performed, no single exercise showed significant difference in the EO and LA activity.

Discussion

The most important findings of this study indicated that there was significantly greater EMG activity in the LSLES and ULES muscle groups during the 80% 1RM squat and deadlift exercises compared to all other exercises. The use of instability devices associated with the global and local stability demands during different core stability tasks on and off a Swiss ball indicated that the performance demands on the Swiss ball did lead to greater activation levels when compared with a stable surface. Additionally, a study by Costa-Lima et al. (8) demonstrated that after 5 weeks of training with a Swiss ball, there were greater gains in torque balance and trunk EMG activity when compared with traditional floor exercises. Bemh et al. (9) have reported that the subjects performed various trunk-stabilizing exercises with stable and unstable (Swiss ball) conditions. Results indicated that the abdominal exercises, LSLES, and ULES exhibited significantly greater activity with the unstable condition.

Instability training has also been shown to increase the activation levels of other muscles besides those of the trunk region. A study by Keen et al. (12) examined the effects of using unstable exercise equipment on gait, and typically directed infants, children, and adolescents to train on unstable surfaces such as trampolines, balance beams, and gymnastic rings. The results indicated that the unstable, increased stabilization function of the muscles was not enough to maintain balance and therefore decreased EMG levels during the unstable exercises. In addition, there was greater trunk activation during unilateral dumbbell press of the contralateral arm compared with the ipsilateral arm or bilateral press (5).

Not all instability studies have provided evidence of increased EMG activity in the trunk muscles. Shibya and Behm (1) had subjects perform chest press exercises under stable and unstable conditions. Electromyographic results were not able to produce changes in the trunk muscles, the pectoral major, anterior deltoid, triceps brachii, latissimus dorsi, and rectus abdominis. Results showed that there was no significant difference in EMG activity between the stable and unstable chest presses. In addition, the unstable base elicited a 60% decrease in maximum pressure. These findings are supported by data that suggests even though external forces are being imposed on the body, the body may not always be able to maintain stability due to the greater reliance of the limb muscles on joint stabilization (3).

On the contrary, a study by Bemh et al. (3) showed that there was a decrease in quadriceps and planar flexors muscle activity under unstable conditions. The study had subjects perform various exercises on the unstable and stable conditions. Activity averaged 44.3 and 29.9% less, respectively, in comparison with the stable conditions. In addition, leg extensor force was 70.6% lower under unstable conditions, whereas planar flexor force decreased by 59.4%. The findings suggest that increased EMG instability, the increased stabilization function of the muscles was not enough to maintain balance and therefore decreased EMG levels during the unstable exercises. Typically, unstable calisthenic-type exercises are performed while in a supine or prone position. However, these exercises mimic many of the movements of daily life (e.g., lifting), whereas other traditional resistance training exercises (e.g., squats, deadlifts) do not. This study provides evidence that unstable training devices incorporate the program as a variation or modification from traditional resistance training exercises. With this in mind, it is the stabilizing rules of these muscles. Andersen and Behm (2) investigated the differences between the two muscle groups, including the LSLES, and ULES groups, while performing squats of different stability and resistance. The squats movement was performed on the stable surface, as a foam, and while standing on 2 bouncing discs. Results indicated that the LA, ULES, and LES, and soleus muscle groups were activated to a greater degree when performing the movement under unstable conditions. The authors attributed this to the increased demand in coupling the movements with modifications of the trunk muscles. Bemh et al. (4) compared EMG activity in the trunk muscles during popular resistance exercises and found that the trunk muscles were activated to a stable and unstable tests. In addition, they compared the activation of the trunk muscles with modifications of unilateral and bilateral exercises and found that the activation could be increased. Results indicated that there was an overall increase in lower abdominal muscle activation (EMG) levels during the unstable exercises. In addition, there was greater trunk activation during unilateral dumbbell press of the contralateral arm compared with the ipsilateral arm or bilateral press (5).

The 80% 1RM squat exercise exhibited significantly (p = 0.0096) greater LSLES EMG activity than all other exercises (Figure 1). Squat LSLES EMG activity at 80% 1RM significantly (p = 0.0027) exceeded the performance of dynamic, weightlifting exercises and isometric instability exercises. Bars depict the mean combined data of the individual exercises. Asterisks indicate that the exercise was significantly different from all other exercises. X-axis titles represent the following squats: squat 80% 1RM, squat 80% 1RM maximum (1RM), deadlift 80% 1RM, deadlift 80% 1RM, BW, squat and deadlift using only body weight as a resistance. Vertical bars represent SD.
tion to the counterbalancing action of the torso during the squat movement, the LSES also involves handling compressive forces. Although the local stability muscles of the spine have a role in maintaining segmental stability, they often need the aid of the large global muscles during certain movements, such as the squat exercise. More global muscles represented in the present study by the ULES EMG activity help to provide the bulk of stiffness to the spine, as well as generate force to control range of motion (9). Thus, while a person performs a movement (e.g., squat, deadlift), the local stabilizers help to maintain mechanical ability and posture of the lumbar spine and the global muscles function to balance the external load that is being applied to the trunk region and generate force in order to maintain the range of motion for the exercise (9).

With the deadlift exercise, it is plausible that the greater activation of the ULES was evoked due to the recruitment of the upper back muscles in order to both dynamically lift the weight off the floor and stabilize the thoracic and lumbar vertebrae. In the current study, subjects used a quarter-squat position to lift the weight off the floor. In the quarter-squat position, the hips are placed in a higher position during the initial pull of the weight compared with a half-squat position, in which the hips are lower, thus putting the initial load of the pull onto the quadriceps muscles with less stress on the lower lumbar region of the spine (12). Similar to many activities of daily living, the deadlift necessitates the integration of contractile muscle mass, isometric contractions, and stabilization. It was also apparent that performing such movements as squats and deadlifts without external resistance provided similar trunk activation as the selected unstable exercises. As previously mentioned, the move associated with the inverted pendulum-like action of the body would necessitate corrective muscular actions by the dorsal trunk musculature.

Conclusion

The current study indicates that dynamic exercises, such as the squat and deadlift, incorporating high-intensity resistance paired with moderate instability can increase the muscle activity of the trunk region to a greater degree than selected isokinetic instability exercises. Thus, it may be unnecessary to add calisthenic-type instability exercises to a training program to promote core stability if full-body, dynamic, isotonic exercises are implemented in the program.

Practical Applications

Whereas a number of studies have demonstrated greater trunk muscle activation when comparing similar unstable with stable exercises (5, 15), the present study illustrates the high trunk muscle activation needed to stabilize external resistance during traditional weight-training exercises, such as the squat and deadlift. The common notion regarding the necessity to add instability device exercises to a traditional resistance training program to accentuate trunk activation has been shown to be unnecessary if such exercises as the 80% 1RM squat and deadlift are included in the program. Individuals who do not incorporate such resisted compound muscle actions in their training or those who wish to provide activation over a greater range of motion (24) may wish to add instability device exercises.

References