

The Effects of Push-ups with the Trunk Flexed on the Shoulder and Trunk Muscles

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Abstract. [Purpose] The purpose of this study was to compare the activity of the shoulder and trunk muscles in two push-up positions: standard push-ups and push-ups with the trunk flexed. [Subjects] Fifteen young adult males participated in the study. [Methods] This study measured the clavicular and sternocostal portions of the pectoralis major, the serratus anterior, and the rectus abdominis during push-ups under the two conditions. [Results] The activity of the sternocostal portion of the pectoralis major and that of the rectus abdominis were significantly greater under Condition 1 than under Condition 2. The activity of the clavicular portion of the pectoralis major and that of the serratus anterior were significantly greater under Condition 2 compared with Condition 1. [Conclusion] These results indicate that exercises can selectively activate muscle parts under different clinical situations.

Key words: Electromyography, Push-up, Selective muscle activation

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INTRODUCTION

Push-ups are used for many purposes, including strengthening the upper body, rehabilitating the shoulder, stabilization training of dynamic joints, and improving proprioceptive feedback mechanisms^{1, 2)}. Among the various exercises that are generally used to strengthen the shoulder and upper extremity muscles, the push-up is classified as a closed chain exercise and is used to strengthen the pectoralis major, triceps brachii, and shoulder stabilizing muscles³⁾. Recent studies have examined the effects of variation in the push-up position, including rotation of the hand/wrist, different distances between the palms, changing the height of the legs, and performing push-ups on an unstable surface⁴⁾. Despite the many advantages of the exercise, push-ups also have negative consequences, such as low-back pain, because the push-up position places much resistance on the trunk muscles, which can place a huge load on the lumbar vertebrae⁵⁾. Changing the push-up position can affect the abdominal and vertebral muscles and lumbar angle and load⁵⁾. Therefore, the purpose of this study was to compare the activity of the shoulder and trunk muscles in two push-up positions: standard push-ups and push-ups with the trunk flexed.

SUBJECTS AND METHODS

Fifteen young adult males with no history of musculoskeletal disorders or pain associated with the upper or lower extremities in the past 6 months participated in the study. Their average age, height, and weight were 21.2 ± 2.4 years, 173.1 ± 5.13 cm, and 62.27 ± 5.26 kg, respectively. The study was approved by the Inje University Faculty of Health Science Human Ethics Committee, and the subjects provided written informed consent before participating. Electromyography (EMG) data were collected using a Biopac MP150WSW (Biopac Systems, Santa Barbara, CA, USA). All EMG signals were amplified, band-pass filtered (20–450 Hz), and sampled at 1,000 Hz using AcqKnowledge ver. 3.9.1. The root mean square values of the raw data were calculated for 250 samples, with the amplitude normalized to the maximum voluntary isometric contraction. We measured the clavicular and sternocostal portions of the pectoralis major, the serratus anterior, and the rectus abdominis on the right side during push-ups under two conditions: the standard position with the body forming a straight line (Condition 1) and the experimental position with the waist flexed at 30° (Condition 2). The order of the two conditions were selected randomly. Subjects placed their feet horizontally on a wooden scaffold and assumed the push-up position by grabbing a push-up bar with their hands at shoulder width. The subjects performed the exercise after an instructor's command. Each position was repeated twice. Each push-up consisted of lowering the body over a period of 2 seconds and returning to the start position over another 2 seconds. The mean value of muscle activity during the 2 seconds when returning to the start position was analyzed from the EMG data. There was a 3-min

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break between conditions. The paired t-test (SPSS ver. 18.0; Chicago, IL, USA) was used to analyze differences in the normalized EMG muscle activity of the right clavicular and sternocostal portions of the pectoralis major and the triceps brachii, serratus anterior, erector spinae, and rectus abdominis muscles between Conditions 1 and 2. Significance was defined as $p < 0.05$.

RESULTS

The activity of the sternocostal portion of the pectoralis major and that of the rectus abdominis were significantly greater under Condition 1 than under Condition 2 ($p < 0.05$). In contrast, the activity of the clavicular portion of the pectoralis major and that of the serratus anterior were significantly greater under Condition 2 compared with Condition 1 ($p < 0.05$) (Table 1).

DISCUSSION

We found that the activity of the clavicular portion of the pectoralis major and that of the serratus anterior was significantly greater when the push-up was performed with the trunk flexed. The serratus anterior plays an important role in the stability of the scapula, and several studies have examined various exercises for selectively strengthening this muscle^{6, 7}. In the push-up with the trunk flexed, the weight of the upper extremity is directly loaded on the serratus anterior as the center of the upper body is moved forward. Thus, performing a push-up with the trunk flexed significantly increases the activity of the clavicular portion of the pectoralis major, whereas in a traditional push-up, the activity of the sternocostal part of the pectoralis major is significantly greater. These results indicate that exercises can selectively activate muscle parts under different clinical situations. Excessive hyperlordosis is said to be the main cause of positional pain, facet joint pain, and nerve root disease⁸, and the abdomen and back muscles affect pelvic tilt and lordosis⁸. Because the abdominal muscles originate from the iliac crest and pubic symphysis and insert at the xiphoid process of the 5th to 7th rib cartilage, posterior pelvic tilt is possible, which alters the lumbar intervertebral curve⁹. In a traditional push-up, the activity of the rectus abdominis is significantly greater than that in the push-up with the trunk flexed. We found that push-ups with the trunk flexed decreased the resistance of the abdominal muscle needed

Table 1. Comparison of EMG data between the 2 conditions

Muscles	Mean \pm SD (%MVIC)	
	Condition 1	Condition 2
cPM	79.1 \pm 18.0	84.3 \pm 17.4*
sPM	64.5 \pm 18.3*	55.2 \pm 23.4
SA	45.5 \pm 19.4	57.4 \pm 24.4*
RA	21.8 \pm 14.5*	15.1 \pm 12.0

to maintain position compared with a traditional push-up by controlling excessive extension of the lower back. Push-ups with the trunk flexed are required to improve shoulder flexion posture, so physical therapists should pay attention to this when treating shoulder pain patients.

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