Effect of Hand Grips and a Labile Surface on Upper Extremity Muscle Activities during Push-up Exercise on a Multi-Function Balance Board

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Abstract. [Purpose] The aim of this study was to reveal the effect of using hand-grips and a labile surface during push-up exercise. [Subjects] We recruited 12 male subjects. [Methods] Push-up exercises were performed under four different conditions on a multi-function balance board: a stable surface with and without hand-grips, a labile surface with and without hand-grips. Muscle activities of the upper trapezius (UT), serratus anterior (SA), extensor carpi radialis (ECR), and flexor carpi ulnaris (FCU) muscles were recorded. [Results] Push-ups on the labile surface tended to increase greater activation of the SA, and significantly increased both UT and FCU activities compared with the same exercise on the stable surface regardless of hand-grip usage. Push-ups on the labile surface with hand-grips condition caused significantly increased in ECR activation compared to other conditions. [Conclusion] Usage of hand-grips is recommended when push-ups are performed on a labile surface to reduce muscular imbalance in the wrist.

Key words: Electromyography, Hand-grips, Support surfaces

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INTRODUCTION

Previous studies have described the muscular activation that occurs during a conventional push-up. A low speed and a narrow-base for a push up have been suggested to improve the efficiency of muscle training^{1, 2)}. Recent studies on the effects of a labile surface and the use of hand-grips on muscular activation during push-up exercise³⁻⁶⁾ have reported higher activation of the upper trapezius (UT) during push-ups on a labile surface^{3, 7)}. Although hand-grips are in general use for push-ups, the effects of hand-grip use on muscle activation have rarely been reported. In addition, no study has focused on the forearm muscles, which are directly influenced by hand position. The wrist is a flexible joint⁸⁾, which suggests that use of a hand-grip could change the forearm muscular activity, especially when the exercise is performed on a labile surface. In order to compare push-ups performed on stable and unstable surfaces, with and without hand-grips, we devised a multi-function balance board (MFB) with detachable hand-grips that can provide information about balance. The purpose of present study was to use this MFB to investigate the effects of using hand-grips and a labile surface during push-ups.

SUBJECTS AND METHODS

The subjects were 12 males aged 23.7 ± 2.3 years (mean $\pm$ SD), whose average height was 175.3 ± 3.8 cm, and average body weight was 67.4 ± 6.9 kg. None of the subjects had any musculoskeletal disorder or pain in the upper extremities. Activations of the serratus anterior (SA), upper trapezius (UT), extensor carpi radialis (ECR), and flexor carpi ulnaris (FCU) muscles were recorded by electromyography (EMG) (Delsys, Boston, MA, USA). The EMG signals were sampled at 2000 Hz, with band pass filtering between 20 and 450 Hz. Six Trigno electrodes were attached to right dominant side of each subject⁹⁾. Four push-up conditions were examined in the present study: push-ups on a stable surface (PS); push-ups performed with hand-grips on a stable surface (PHS); push-ups on a labile surface (PL); and push-ups performed with hand-grips on a labile surface (PHL). A newly designed MFB, which incorporates detachable hand-grips and labile support, was used and a digital level gauge provided visual feedback of horizontality. The degree of horizontality was presented as a % of horizontality with respect to the initial calibration. Each subject was asked to perform a descending push-up in two seconds, until they touched a cup marker placed on the surface, and then to ascend in two seconds. The speed was regulated with a metronome. The maximal voluntary contraction (MVC) of

Table 1 . Normalized EMG data for UT, SA, ECR and FCU under the different push-up conditions

Mean $\pm$ SD (%MVC)	Push-up without hand-grip		Push-up with hand-grip	
	Stable surface	Labile surface	Stable surface	Labile surface
UT	11.48 $\pm$ 7.34	25.06 $\pm$ 12.32*	13.85 $\pm$ 8.89	26.16 $\pm$ 16.16*
SA	27.28 $\pm$ 8.67	34.48 $\pm$ 12.62*	23.39 $\pm$ 7.19	28.49 $\pm$ 9.49
ECR	8.51 $\pm$ 6.48	10.98 $\pm$ 8.16	8.56 $\pm$ 3.51	21.33 $\pm$ 7.21*
FCU	23.21 $\pm$ 16.89	51.11 $\pm$ 24.53*	22.93 $\pm$ 9.11	44.3 $\pm$ 13.92*

each muscle was measured to normalize the EMG signal⁹⁾. One-way repeated-measures ANOVA was conducted to test for differences in each muscle's %MVC among the conditions using the SPSS statistical package (version 18.0; SPSS, Chicago, IL, USA). Significant main differences were determined using the Bonferroni correction. Significance was accepted for values of $p < 0.05$.

RESULTS

The %MVC of the SA differed significantly among the conditions. The PL condition showed caused significantly increased SA activation compared with the PS and PHS conditions ($p < 0.05$). Significant differences were seen in the %MVC values of UT, ECR, and FCU. The PL and PHL conditions significantly increased UT and FCU compared to the PS and PHS conditions, regardless of the use of hand-grips ($p < 0.05$). The %MVC of the ECR under the PHL condition was significantly higher than that of the other PS, PL, and PHS conditions ($p < 0.05$) (Table 1).

DISCUSSION

This study examined 4 categories of muscular demand: low (20% MVC), moderate (20–40%), high (41–60%), and very high (61%–100%)¹⁰⁾. The push-up used in the present study moderately strengthens SA and FCU. To activate both UT and SA at a moderate level, the use of a labile surface is recommended. However, previous findings agreed that minimizing the activity of the upper trapezius and activating the serratus anterior, helps to regain glenohumeral rhythm^{10, 11)}. Therefore, push-ups on a labile surface should be carefully performed by patients with shoulder disorders. A significant increase was observed in the UT, SA, and FCU under the labile surface conditions. A previous study that used a balance board reported UT results that were similar to those of the present study³⁾. Under the PHL and PL conditions, balance was maintained by watching the level gauge on the MFB. The proximal musculature that attaches to the scapulae may be more activated in order to maintain the scapular position¹²⁾. Although we did not measure the kinematics of the wrist, the higher activation of FCU observed under the PL and PHL conditions might have been due to increased ulnar deviation. The hand position may influence shoulder muscle activation during a

push-up^{2, 5)}. Rotatable hand-grips have been reported not to enhance scapulothoracic muscular recruitment⁵⁾, similar to what we found in the present study. The use of hand-grips appeared to require less anterior-posterior and medio-lateral force than palm or fist push-ups. Our opinion is that, under the PHL condition, the ECR counteracts the FCU activation, which contributes to maintenance of the neutral position of the wrist joint by grasping the hand-grip⁸⁾.

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