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Original Article

Effects of isometric hip movements on electromyographic activities of the trunk muscles during plank exercises

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Abstract. [Purpose] The purpose of this study was to investigate the effect of isometric hip adduction and abduction on trunk muscle activity during plank exercises. [Subjects and Methods] Nineteen healthy male subjects were recruited for this study. All subjects performed the traditional plank exercise (TP), plank exercise with isometric hip adduction (PHAD), and plank exercise with isometric hip abduction (PHAB) by using an elastic band. Electromyographic (EMG) activities of the internal oblique (IO) and external oblique (EO) were measured during the 3 plank exercises by using an Electromyography system. [Results] Internal oblique and external oblique muscle activities were significantly greater during plank exercise with isometric hip adduction and plank exercise with isometric hip abduction than during traditional plank exercise. Internal oblique and external oblique muscle activities did not differ between the plank exercise with isometric hip adduction and plank exercise with isometric hip abduction conditions. [Conclusion] These findings demonstrate that loaded isometric hip movements may be a useful strategy to increase trunk muscle activity during plank exercises.

Key words: Electromyography, Isometric hip movement, Plank exercise

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INTRODUCTION

Trunk stability is crucial in treating and preventing low back pain[1)]. The plank exercise has commonly been used to improve trunk stability in the context of physical therapy[2, 3)]. Compared with other trunk stability exercises, such as sit-ups, the plank exercise is performed without excessive lumbar flexion, which prevents greater compression forces on the lumbar spine[4)]. Thus, the plank exercise has been suggested as a useful and safe trunk stability exercise.

The abdominal oblique muscles, including the internal oblique (IO) and external oblique (EO), play important roles in improving trunk stability because they act as global stabilizers of the trunk[1)]. To increase the electromyographic (EMG) activities of the abdominal oblique muscles, additional limb movements are often performed in a neutral spine position[5)]. These limb movements induce greater trunk muscle activity against the added postural demand that they cause[6)]. Lee et al.[5)] demonstrated that EMG activities of the trunk muscles were significantly influenced by the direction of arm movements. Other previous studies have explored the influence of loaded arm movements on the activities of the trunk and hip muscles[5, 7)]. To the best of our knowledge, no study has examined whether loaded hip movements influence trunk muscle activity during the plank exercise. Therefore, the aim of the present study was to examine the effects of isometric hip adduction and abduction on EMG activities of the trunk muscles during plank exercises.

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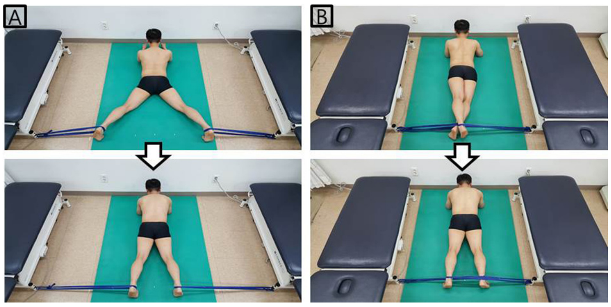

Fig. 1. Plank with isometric hip adduction (A) and plank with isometric hip abduction (B) using elastic bands

SUBJECTS AND METHODS

In total, 19 healthy male subjects (mean age, 29.4 ± 3.0 years; mean height, 174.6 ± 5.4 cm; mean weight, 73.0 ± 6.2 kg) participated in this study. Potential subjects who had a history of lumbar spine surgery, or who had difficulty maintaining a neutral lumbar position during plank exercises, were excluded from this study. Before the experiment, all participants signed an informed consent form approved by the Institutional Research Review Committee of Inje University. The study protocol complies with the ethical standards of the Declaration of Helsinki.

The wireless TeleMyo DTS (Noraxon, Inc., Scottsdale, AZ, USA) was used to measure EMG activities of the IO and EO muscles in the non-dominant leg side. The sample rate was 1,000 Hz, with a bandpass filter of 20–450 Hz and notch filters at 60 Hz. All raw EMG data were converted to root mean square data for analysis purposes. Electrode placements for the IO and EO were determined according to Criswell[8]. The site for each electrode was shaved and then cleaned with alcohol and cotton to reduce skin impedance. To normalize EMG activities of the IO and EO muscles, maximum voluntary isometric contractions (MVICs) of the abdominal oblique muscles were measured using maneuvers suggested by previous studies[5, 9]. All subjects performed the traditional plank (TP), plank with isometric hip adduction (PHAD), and plank with isometric hip abduction (PHAB) in a randomized order. Under the TP condition, subjects were asked to flex the shoulder and elbow at 90° and to maintain forearm and toe contact with the ground in the prone plank position, while also maintaining a neutral spine with the legs extended[2, 3]. Two poles were placed next to the feet at distances of 1 m from each ipsilateral foot for PHAD, while 2 poles were placed at distances of 1 m from each contralateral foot for PHAB. Two blue elastic bands (Thera Band, Hygenic Corp., Akron, OH, USA) of 60 cm length were attached to the poles. The other ends of the bands were attached to the subjects' lower legs above the ipsilateral medial malleolus for PHAD and above the contralateral lateral malleolus for PHAB. All subjects were asked to adduct or abduct the hips into a neutral hip position and then perform the designated plank exercise (Fig. 1). Subjects were instructed to perform both the PHAD and PHAB plank exercises, with the band stretched to 40 cm. This length was determined based on a pilot study showing that all subjects could perform more than 10 repetitions of PHAD and PHAB by using 40 cm of stretched elastic band[10]. Each plank exercise was performed for 5 s and repeated 3 times, with a 1-min rest period between trials. The average value of the middle 3 s of the test trials was used for data analysis. Differences in IO and EO EMG activities among conditions were analyzed using one-way repeated-measures analysis of variance with the Bonferroni correction. PASW Statistics software (ver. 18.0; SPSS, Inc., Chicago, IL, USA) was used for statistical analyses. The level of statistical significance was set at 0.05.

RESULTS

EMG activities of the IO ($p=0.001$) and EO ($p=0.013$) were significantly different among conditions. Significantly greater IO muscle activity was found in PHAD (40.9 ± 17.8%MVIC vs. 34.5 ± 14.8%MVIC, $p=0.006$) and PHAB (44.6 ± 19.0%MVIC vs. 34.5 ± 14.8%MVIC, $p<0.001$), compared with TP. Furthermore, EO muscle activity was significantly greater in PHAD (47.9 ± 15.1%MVIC vs. 42.0 ± 13.6%MVIC, $p=0.028$) and PHAB (48.4 ± 15.4%MVIC vs. 42.0 ± 13.6%MVIC, $p=0.016$), compared with TP. However, there was no significant difference in EO and IO muscle activities between PHAD and PHAB ($p>0.05$).

DISCUSSION

The present study demonstrated that isometric hip movements lead to greater EMG activities of the IO and EO muscles during plank exercises ($p<0.05$). IO and EO muscles are linked to contralateral hip adductor muscles through the anterior oblique sling system[11]. In the muscle sling system, muscles work together to provide not only functional movement but also stabilization[12]. Thus, we consider that hip adductor muscle may facilitate contralateral IO and EO muscles via the muscle sling system during PHAD. In addition, abdominal muscle activities were greater in the PHAB than in the TP condition ($p<0.05$). Considering a previous finding that shoulder abduction facilitated EMG activities of the contralateral abdominal muscles in response to postural demand[13], it is reasonable that hip movements also facilitate contralateral abdominal muscle activities to maintain neutral trunk alignment. Moreover, isometric contraction of the hip abductor using an elastic band creates greater demand, requiring greater activities of the contralateral abdominal muscles. However, no significant differences in IO and EO muscle activities were found between the PHAD and PHAB conditions ($p>0.05$). Because isometric hip adduction and abduction were performed bilaterally in the present study, contralateral hip movement provided counterforce, equal in magnitude, against the force caused by ipsilateral hip movement. Thus, destabilization force on the trunk may have been decreased compared to unilateral hip movements, which may explain the absence of significant differences in IO and EO muscle activities between the 2 conditions.

The present study had several limitations. First, it is difficult to generalize our findings to all populations because only healthy male subjects were recruited for this study. Second, only bilateral isometric hip movements were performed in this study. Future studies need to examine the effects of unilateral loaded isometric hip movements on trunk muscle activity during plank exercises.

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