

Difference in Muscle Activities According to Stability on Support Surface During Plank Exercise

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| Abstract |

PURPOSE: The present study aimed to measure muscle activities in the pectoralis major, the erector spinae, and the quadriceps femoris according to support surface states of arms and legs during plank exercise.

METHODS: The subjects of this study were 21 healthy males in their 20s and their muscle activities at three states were measured as follows: The first state was where the support surface of arms and legs was stable. The second state was where only arms were unstable, and the third state was where only legs were unstable. Electromyography (EMG) was used to measure muscle activities. Pectoralis major, quadriceps femoris, and erector spinae were measured for muscle activities.

RESULTS: The muscle activities in the pectoralis major were statistically high when arms were unstable. The muscle activities in the quadriceps femoris were statistically high when legs were unstable. The muscle activities in the erector spinae were higher when arms and legs were unstable compared to that at the stable support surface. No significant

difference was revealed statistically when arms and legs were unstable.

CONCLUSION: If the instability of arms and legs is employed during plank exercise, exercise on the upper and lower bodies or the erector spinae is expected to be more effective.

Key Words: EMG, Muscle activity, Plank exercise

I. Introduction

The muscles in the trunk play an important role in supporting the center of body. Thus, the stability of trunk muscles is highly important to basic stability for movements of upper extremities and correct alignment of spine (Lehman et al., 2005). A lower back pain, which is one of the most common musculoskeletal disorders in modern people, is also caused by instability around the trunk and imbalance of muscles (Hodges, 2003). A sit-up exercise is frequently performed to increase muscle strength in trunk muscles but it can increase a pressure on the spine thereby causing a problem in the lumbar spine. In particular, it can be more aggravated in patients with lower back pain (McGill, 2010).

In recent years, the plank has been widely done instead of doing sit-ups to overcome the above problems. The plank

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increases activities of abdominal muscles among trunk muscles thereby strengthening trunk muscles without too much pressure on the spine (Snarr and Esco, 2014). The movements and activities of arms and legs affect the motion of the trunk. An increase in abdominal muscles was exhibited through limb movements, and activities in abdomen were higher when alternating movements of limbs were performed. Although differences can be found in the plank via limb's movements, differences can also be found via differences in support surface of arms and legs that support the floor (Hodges et al., 1999; Lee et al., 2013). Although a number of studies have been conducted on the plank as an exercise to increase muscle activities and muscle strength in abdomen, few studies have been conducted on muscles according to a support surface (Kim et al., 2016). Depending on the support surface of the floor, changes in muscle activities in trunk, arms, and legs were found during push-ups (Cho and Choi, 2016; Seo et al., 2013). Studies on the plank have been focused on strengthening abdominal muscles among trunk muscles (Tong et al., 2014).

Thus, the this study aimed to determine muscle activities according to a state of support surface in light of the consideration that muscle activities in trunk and limb muscles would be different according to a support surface during the plank as same as muscle activities are different according to a difference in support surface during push-ups. That is, the plank is an exercise that places lower arms and legs on the floor, so this study expected muscle activities would be different according to the stability state in the floor, which was why this study aimed to measure changes in muscle activities according to the state of arms and legs at the floor during the plank.

II. Methods

1. Subjects

The present study was conducted with 21 healthy adult

males in their 20s who had no neurological and musculoskeletal disorders. The subjects were informed about the study method and consented to participate in the study.

2. Study procedure

The present study was conducted to determine changes in muscle activities of body muscles according to the state of support surface during the plank. The state of support surface was divided into three: both of arms and legs were all stable (Double-Stable Support: D-SS), only arms were unstable (Arm-UnStable Support: A-US), and only legs were unstable (Leg-UnStable Support: L-US). The Togu ball was used to make an unstable state in the arms and legs as well as two pads to make arms unstable, and one pad to make legs unstable. The patients were performed 3 times exercise for precise movement. After 10 seconds of the plank, data were collected for five seconds, and a rest time was given for five minutes between exercises (Lee et al., 2012). Furthermore, every seven subjects had a different exercise order to reduce a difference due to exercise order. Electromyography (EMG) was used to measure muscle activities. Pectoralis major, quadriceps femoris, and erector spinae were measured for muscle activities. In previous studies, many muscles were measured for muscle activity during plank or push up exercise. Among them, we chose pectoralis major, quadriceps femoris, erector spinae for measuring trunk and low extremity activity (Byrne et al., 2014; Harris et al., 2017; Snarr and Esco, 2014).

Their muscles activities were measured using an MP150 (BIOPAC systems, Inc., Goleta, CA, USA), surface electromyography equipment, and Ag-Ag/Cl electrodes. The attachment position of the electrodes was in each muscle belly. The ground electrode was attached to an area not associated with signals. Signals collected at a sampling rate of 1,000 Hz were notch filtered at 60 Hz after full-wave rectification to remove electrical noise. Then, 30 to 500 band-pass filtering was conducted. % Maximal Voluntary

Table 1. Changes muscle activities in condition (unit : %MVIC)

Muscle	D-SS	A-US	L-US
PM	43.14±5.65	54.85±8.56* [‡]	45.51±7.51
QF	47.56±6.94	50.51±7.51	58.85±8.51* [†]
ES	51.98±5.56	64.83±7.51*	59.89±6.98*

DSS: Double-Stable Support, A-US: Arm-Unstable Support, L-US: Leg-Unstable Support

PM: pectoralis major, QF: Quadriceps Femoris, ES: Erector Spinae

CG: control group, EG: experimental group

* significant difference compared to D-SS

[†] significant difference compared to after A-US

[‡] significant difference compared to after L-US

p<.05

Isometric Contraction test (MVIC) was employed for normalization. A maximal voluntary isometric contraction was carried out based on the manual muscle test.

3. Statistical analysis

SPSS was used for statistical analysis of muscle activities. Repeated measurements were performed to determine muscle activity by condition. A statistical significance level was set at .05.

III. Results

This study group was shown to be 22.85±2.12 years, 172.51±15.51 cm, 70.64±5.65 kg. There was significant difference the pectoralis major muscle activity between D-SS and A-US, L-US and A-US (p<.05). In quadriceps, femoris was significant difference between D-SS and L-US, A-US and L-US (p<.05). There was significant difference muscle activity between D-SS and A-US, D-SS and L-US in the erector spinae (p<.05).

IV. Discussion

In this study, a difference in muscle activities was compared during the plank according to a stable state of

arms and legs. The subjects placed their arms and legs on a support surface whose stable state was different, and then differences in muscle activities were compared. First, the pectoralis major showed a significant difference according to the state of the support surface statistically. Previously, no studies have been conducted on differences in muscle activities due to a difference in support surface during the plank exercise. However, compared to a previous similar study that exhibited a difference in muscle activities of shoulders and trunk according to a state of support state during push-up exercise, the present study also showed a difference in muscle activities when instability of support surface on the floor was high (Seo et al., 2013). In the previous study, muscle activities around shoulders were significantly higher in an unstable support surface against arms than in a stable support surface statistically. The present study also exhibited significantly higher muscle activities statistically during the plank when arms were unstable than arms on stable support surface. A mean value of muscle activities in legs was higher when legs were unstable than legs on the stable surface. However, it did not show a significant difference statistically. This result was consistent between previous and present studies, which indicated that the effect of the exercise can be increased if more muscles were mobilized during push-ups or the plank using unstable support surface to increase the effect of the exercise around the shoulders.

Second, muscle activities in the quadriceps femoris showed also a significant difference statistically according to the state of support surface. The muscle activities were statistically higher when legs were unstable than those at the stable support surface or when arms were unstable. The muscle activities in the quadriceps femoris were higher when arms were unstable than when arms were stable but a statistically significant difference was not revealed. Push-up exercise can make a difference in muscle activities around the shoulders according to the unstable state of arms and legs (Lehman et al., 2008). In his study, muscle activities in the upper trapezius were higher when arms and legs were unstable than when arms were stable, and the difference was also significantly higher statistically. The change in muscle activities in the upper trapezius reported in the previous study (Lehman et al., 2006). It was also revealed in the present study. However, his study reported that muscle activities in the lower trapezius were higher when legs were unstable than when arms were unstable, which was different from the present study result. The reason for this difference in muscle activities was due to the use of anterior or posterior muscles according to the posture taken during the exercise. The plank exercise employs anterior muscles mainly (Snarr and Esco, 2014). The pectoralis major and the quadriceps femoris measured in the present study are anterior muscles, which exhibited a different pattern of activities compared to that of the lower trapezius but relatively similar result was revealed in the upper trapezius.

Finally, the erector spinae showed somewhat different results compared to that of the above two muscles. The muscle activities were higher when arms and legs were unstable during the plank than when the support surface was stable. A mean value was higher when arms were unstable compared to that when legs were unstable but the result was not significantly different statistically. This was because the erector spinae was affected by activities of trunk directly so that instability at both of arms and

legs affected the trunk thereby increasing muscle activities in the erector spinae. The muscle activities in the trunk were different according to various environments in existing exercises (Imai et al., 2010). Furthermore, previous studies focused on muscle activities in the abdomen during the plank exercise and measured a difference in abdominal muscles at various environments and postures, reporting that muscle activities in the abdomen were different according to environments and postures (Calatayud et al., 2017; Yoo, 2016). The erector spinae is a muscle that is directly responsible for the stability of the trunk as same as the abdominal muscle. Thus, the present study presented that muscle activities in the erector spinae were higher when arms and legs were unstable than when the support surface was stable.

V. Conclusion

The present study result showed that the effect of the plank will be improved if subjects perform the plank at various environments to increase strengthening of specific muscles. Furthermore, the effect of the plank exercise on the erector spinae will also be improved by giving appropriate instability to arms and legs according to muscle strength and conditions of arms or legs while performing exercises for trunks.

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