ISSN 2733-6441 / eISSN 2733-645X http://dx.doi.org/10.26862/jkpts.2020.06.27.1.51

대한물리치료과학회지
Journal of Korean Physical Therapy Science
2020. 06. Vol. 27, No.1, pp. 51-55

Effects of various plank exercises on activation of hamstring muscle

Yoon-A Park · Eun-jin Kim · Ha-yeon Cha · Hee-won Ryu · Young-hoon Seo · Ji-yeon Seong · Jeong-im Hwang, B.Hc., P.T. · Bo-ram Choi, Ph.D., P.T.

Dept. of Physical Therapy, College of Health and Welfare, Silla University

Abstract

Background: A typical plank exercise (PE) strengthens the core muscles, stabilizes the spinal column, and provides stability around the pelvis and trunk when the trunk is aligned. However, because PE require that the hip joint be kept straight, they can activate the hamstring (HAM). Excessive HAM activation can induce tightness, which may cause low back pain. Therefore, it is necessary to explore PE methods that can minimize HAM activity while maximizing core muscle activity.

Design: Cross-sectional study.

Methods: This study included 30 healthy adults as subjects. We measured the activity of the HAM and the erector spinae (ES), rectus abdominis (RA), and external oblique (EO) muscles using surface electromyography during three PEs (typical PE, PE with balance pad, and PE with sling).

Results: The RA, EO, and ES showed the highest muscular activity during PE with balance pad and the lowest during PE with sling; however, the differences were not significant. The HAM showed lower activity during PE with sling than during the other two PEs; however, these differences were also not significant.

Conclusion: Although HAM activation was not significantly difference among PE positions, we should recognize altering activation of core and hamstring muscle according to PE postures.

Key words: Balance pad, Core muscles, Hamstring, Plank exercise, Sling

교신저자: 최보람
주소: 부산광역시 사상구 백양대로 700번길 140(괘법동) 신라대학교 의생명관, **전화:** 051-999-5438, **E-mail:** boram@silla.ac.kr

Ⅰ. Introduction

Plank exercise (PE) resist gravity through activity of the forearms and feet while the subject is in a prone position (Kang et al., 2016; Lee et al., 2016). These exercises stabilize the spinal column and provide stability in the pelvic and trunk regions when the trunk is aligned (Snarr and Esco, 2014). Compared to other body stability exercises such as sit-ups, PEs are performed without excessive lumbar flexion and do not cause posterior disc herniation. For these reasons, PEs are commonly considered useful and safe exercises to promote body stabilization (McGill, 2007; Peterson, 2013).

A typical PE is performed in supine position on the floor, keeping the legs and spine straight while supporting the body with the elbows and toes. This posture strengthens the core, internal oblique (IO), and external oblique (EO) muscles (Snarr and Esco, 2014), reduces the incidence of lumbar injuries, and enhances performance activity (Cho, 2010; Nadler et al., 2002). Variations on the typical PE have attempted to enhance its core muscle strengthening effects; for example, PE on an unstable supporting surface further increases core muscle activity, and the incorporation of slings promotes greater core muscle activity than typical PE (Kang et al., 2016; Lee et al., 2016, Han and Son, 2019). However, because PE requires that the hip joint be kept straight, they can activate the gluteus maximus and hamstring (HAM) (An and Kim, 2017). Although strengthening the HAM can enhance the stability of the hip and knee joints, its excessive activation may induce tightness, which can cause low back pain through posterior pelvic tilt and excessive lumbar flexion (Neumann, 2013, Cho et al., 2019). Moreover, PE on unstable supporting surfaces can increase lower limb muscle activity, leading to excessive HAM activation. Therefore, it is necessary to study PE postures that can minimize HAM activity while maximizing core muscle activity.

Ⅱ. Method

1. Subjects

The subjects of this study were 30 healthy adults. All subjects voluntarily agreed to participate in the experiments after listening to an explanation of the purpose and procedure of this study, provided written consent. Subjects who had received no lumbar treatment within 6 months prior to the study, had no musculoskeletal or neurological disorders, and had no low back pain were included in this study, whereas those who did not consent to the experiment were excluded <Table 1>.

Table 1. Characteristics of subjects (*N*=30)

	Subjects
Gender (n)	Men (13), Women (17)
Age (year)	25.48 ± 1.78[a]
Height (cm)	167.11 ± 12.04
Weight (kg)	64.55 ± 8.19

[a]M±SD

2. Electromyography

We measured the activities of the HAM, erector spinae (ES), rectus abdominis (RA), and EO muscles during PE using a surface electromyography (EMG, 4D-SES, RELIVE, Korea). The sampling rate was 1,024 Hz, the band-pass filter was set to 10–500 Hz, and the notch filter was set to 60 Hz. The root mean square (RMS) was calculated at an epoch length of 50 ms. EMG data were analyzed using the RELIVE EMG software (4D-SES, RELIVE, Korea). To minimize skin resistance, we removed subjects' back and thigh skin hair using a disposable razor and wiped off foreign substances using cotton swabs and rubbing alcohol before attaching electrodes. We used disposable bipolar electrodes (Ag/AgCl), with an inter-electrode distance of 2 cm. To standardize the EMG data, we converted the data to % maximal voluntary isometric contraction (MVIC) values. MVIC values were measured by manual muscle testing (Mendell and Florence, 1990). The MVIC of each muscle was measured three times during 5-s contraction. We used the average values of the middle 3 s, having discarded the first and lasts.

3. Plank exercise

Subjects were sufficiently trained to perform the PE examined in this study prior to participation in the experiments. Each subject flexed shoulders and elbows at 90° in a prone position during the three exercises, with only leg position differing between exercises (Do and Yoo, 2015; Schoenfeld et al., 2014). In the typical PE (PE), the spine was maintained in a neutral posture and the subject extended the knees while touching forearms and toes to the floor. In PE with balance pad (PEB), the subject maintained balance while touching the pad with the toes. In PE with sling (PES), a sling was placed on the distal femur during hip extension and knee flexion to inhibit activation of hamstring muscle and adjusted in such a way that the spine was maintained in a neutral posture during exercise. Five sets of each exercise were performed (15 sec exercise, 30 sec rest per set), and a rest of approximately 5 min was provided between exercises. For each exercise, average values of the middle 5 sec (first and last 5 sec discarded) were used for muscle activity data analysis.

4. Statistical analysis

All data were analyzed using the SPSS Statistics 20 software. One-way analysis of variance (ANOVA) was performed to analyze the activities of the four muscles during each exercise. Significance was determined at a level of α=.05.

Ⅲ. Results

The RA, EO, and ES muscles showed the highest muscular activity when PEB was performed and the lowest activity when PES were used; however, there were no significant differences. The HAM showed lower activity during PES than during PEB or PE; however, no significant differences were detected <Table 2>.

Ⅳ. Discussion

In a previous study, a PE performed using a Swiss ball showed a significant increase in the thicknesses of the RA,

Table 2. Comparisons of trunk muscles and hamstring muscle activation between normal length of hamstring group and shortened length of hamstring group

	PE	PEB	PES
RA	173.07 ± 12.92[a]	187.46 ± 17.68	122.77 ± 12.32
EO	94.87 ± 23.85	102.25 ± 31.36	69.97 ± 33.58
ES	24.54 ± 15.11	53.95 ± 11.55	23.03 ± 15.34
HAM	9.47 ± 2.58	9.41 ± 2.44	9.22 ± 2.30

[a]M±SD, PE=typical plank exercise; PEB=plank exercise with balance pad; PES=plank exercise with sling; RA=rectus abdominis; EO=external oblique; ES=erector spinae; HAM=hamstring

EO, and ES muscles (Shin, 2014). PE performed in prone position significantly increased RA, EO, IO, and ES muscle activity as the degree of difficulty increased. Core muscle activity further increased to maintain trunk stability against an unstable supporting surface. In the current study, RA, EO, and ES muscle activity increased more during PEB than during PE; however, no significant differences were detected.

Although previous studies have reported that PES significantly increased EO, RA, and ES muscle activity compared with PE (Lee et al., 2016), the current study detected decreases in the activity of all three muscles. HAM activation was greatest during PE and lowest during PES. In previous studies, exercises were performed with the subject extending the hip and knee joint(Kang et al., 2016; Kim et al., 2016). Knee flexion during exercise may have contributed to the different results obtained in the current study, reducing the external moment arm from the center of the body, and providing less load to the core muscles during PES than during PE. To decrease HAM activity, we asked subjects to place slings under their femurs during knee flexion at insufficient activity; however, this PE modification did not significantly reduce HAM activity.

This study was limited by the small number of participants, making it difficult to compare our results with those of other studies. Future studies should increase the number of subjects and establish multiple treatment groups to allow more meaningful comparisons. In addition, HAM activity should be determined while subjects perform PEs with knee joints extended and a sling placed at the ankles to examine differences when measurements are conducted with the knee joint flexed.

Ⅴ. Conclusion

In this study, we asked subjects to perform PEs using slings and with their knees flexed to identify a PE that could minimize HAM activity while maximizing core muscle activity; however, the exercise did not significantly affect either activity. Therefore, it is necessary to conduct further research on changes in HAM activity during various types of PE under different conditions.

Reference

An J, Kim KH. Effects of Core Exercise Using Pressure Biofeedback Unit on Muscle Strength of Lower Extremity.

J Korean Phys Ther Sci 2017;24(2):17-26.

Cho SB, Park MY, Won JS, et al. The Effect of Therapeutic Ultrasound and Static Stretching of the Hamstring Muscle on Flexibility and Static Balance Ability. J Korean Phys Ther Sci 2019;26(1):45-53.

Cho YH. Effect of isotonic exercise program and core exercise program on isokinetic muscular strength, flexibility, balance, and visual analog scale of teenage soccer player [master thesis]. Kyung Hee Univ.;2010.

Do Y, Yoo W. Comparison of the thicknesses of the transversus abdominis and internal abdominal obliques during plank exercises on different support surfaces. J Phys Ther Sci 2015;27(1):169-170.

Han WJ, Son KH. The Effect of Unstable Support Surface Plank Exercise on Flexibility, Abdominal Muscle Thickness and Pain in Chronic Low Back Pain. J Korean Phys Ther Sci 2019;26(3):23-36.

Kang K, Son S, Ko Y. Changes in abdominal muscle thickness and balance ability on plank exercises with various surfaces. J Korean Phys Ther 2016;28(5):264-268.

Kang M, Kim S, Kang M, et al. Effects of isometric hip movements on electromyographic activities of the trunk muscles during plank exercises. J Phys Ther Sci 2016;28(8):2373-2375.

Kim S, Kang M, Kim E, et al. Comparison of EMG activity on abdominal muscles during plank exercise with unilateral and bilateral additional isometric hip adduction. J Electromy Kinesio 2016;30:9-14.

Lee J, Jeong K, Lee H, et al. Comparison of three different surface plank exercises on core muscle activity. Phys Ther Rehabil Sci. 2016;5(1):29-33.

McGill S. Designing back exercise: From rehabilitation to enhancing performance. Guide to training the flexion-intolerant back;2007.

Mendell JR, Florence J. Manual muscle testing. Muscle Nerve 1990;13(S1):S16-S20.

Nadler SF, Malanga GA, Bartoli LA, et al. Hip muscle imbalance and low back pain in athletes: Influence of core strengthening. Med Sci Sports Exer 2002;34(1):9-16.

Neumann DA. Kinesiology of the musculoskeletal system-e-book: Foundations for rehabilitation. Elsevier Health Sciences;2013.

Peterson DD. Proposed performance standards for the plank for inclusion consideration into the navy's physical readiness test. Strength Cond J 2013;35(5):22-26.

Schoenfeld BJ, Contreras B, Tiryaki-Sonmez G, et al. An electromyographic comparison of a modified version of the plank with a long lever and posterior tilt versus the traditional plank exercise. Sports biomech 2014;13(3):296-306.

Shin Y. Comparison of core stabilizer muscle activity according to movement difficulty and stability during various trx plank. Off J Kor Acad Kinesio 2014;16(4):31-41.

Snarr RL, Esco MR. Electromyographical comparison of plank variations performed with and without instability devices. J Strength Cond Res 2014;28(11):3298-3305.

[논문접수일(Date Received): 2020.04.06. / 논문수정일(Date Revised): 2020.04.23. / 논문게재승인일(Date Accepted): 2020.05.21.]