ISSN 2733-6441 / eISSN 2733-645X http://dx.doi.org/10.26862/jkpts.2022.06.29.2.14

대한물리치료과학회지
Journal of Korean Physical Therapy Science
2022. 06. Vol. 29, No. 2, pp. 14-19

Comparison of hamstring muscles activity between subjects with normal and shortened hamstring muscle during plank exercise

Bo ram Choi, Ph.D., P.T.

Dept. of Physical Therapy, College of health and welfare, Silla University

Abstract

Background: Plank exercise (PE) is an effective exercise to enhance lower back stability by strengthening the core and lower limb muscles. However, in patients with a shortened hamstring muscle (HAM), PE may cause abnormal movement of the pelvis and lower back due to HAM hyperactivity. Therefore, the objective of this study was to investigate the effects of PE on the core muscles and HAM in subjects with a shortened HAM.

Design: Cross-sectional study.

Methods: Subjects were divided into a normal length of HAM group (NHG; 9 subjects) and a shortened length of HAM group (SHG; 14 subjects). The activities of the erector spinae (ES), rectus abdominis (RA), external oblique (EO), and HAM muscles were measured using surface electromyography.

Results: The results showed that RA, EO, and ES muscle activities were higher in the NHG than in the SHG; however, no significant differences were detected.

Conclusion: HAM activity was significantly higher in the SHG than in the NHG. In subjects with a shortened HAM, PE may hyperactivate the HAM, adversely affecting the pelvis and lower back.

Key words: Core muscles, Hamstring, Muscle shortness, Muscle tightness, Plank exercise.

Corresponding author
Prof. Bo ram Choi
140 Baekyang-daero 700beon-gil, Sasang-gu, Busan. Republic of Korea
T: 051-999-5438, E: boram@silla.ac.kr

 Received 2021-10-04 / Revised 2021-11-09 / Accepted 2021-12-01

Ⅰ. Introduction

Plank exercise (PE) is an exercise commonly used to improve lumbar stability and body movement, and to prevent and rehabilitate back injuries (Snarr and Michael RE, 2014). PE enhances sports performance by increasing the activity of core muscles, such as the external oblique (EO), internal oblique (IO) and transverse abdominis (TrA) muscles (Cosio-Lima et al., 2003; Yoon et al., 2015; Park et al., 2020). Strengthening core muscles through PE can reduce the incidence of back injuries and improve exercise performance (Duncan, 2009). PE is also effective in the prevention and treatment of low back pain, by enhancing the strength and endurance of muscles around the lower back, such as the erector spinae (ES) and multifidus muscles, in turn improving lower back flexibility and balance and ultimately reducing the incidence of back injuries (Kwon, 2008). The core region functions as a movement chain for various activities at the body center; therefore, lower limb function can be enhanced by strengthening the core muscles (de Marche Baldon et al., 2012; Han WJ and Son KH, 2019). Thus, PE can increase stability around the trunk by strengthening the core muscles and improving lower limb muscles strength and endurance, by enhancing the functional connection between the trunk and lower limbs.

Strengthening the hamstrings (HAM) of lower limb muscles can increase the flexibility of the lower back and leg muscles, thereby reducing back pain (An, 2005). In addition, it can increase knee stability through co-activation of the quadriceps femoris muscle (Park, 2006; Oh, 2013). However, a shortened HAM can cause malalignment of the lumbar and pelvis and limit anterior pelvic tilt during lumbar–pelvic rhythm movement, inducing lumbar hypermobility and ultimately resulting in various forms of lumbar-related disease (Kim and Hwang, 2012). PE is an effective exercise to enhance lower back stability by strengthening the core and lower limb muscles; however, it may cause abnormal lumbar and pelvic movement due to HAM hyperactivity when applied to subjects with a shortened HAM. Therefore, it is necessary to investigate the effects of PE on the core muscles and HAM in subjects with a shortened HAM. In this study, we hypothesized that subjects with a shortened HAM would have higher activity in certain muscle groups during PE than subjects with a normal HAM length.

Ⅱ. Methods

1. Subjects

Twenty-three subjects volunteered to participate in this study. The selection criteria included the following: no pain in the lower back or knee joints during the 6 months prior to the study, no current treatment, no musculoskeletal or neurological disorders, and provision of written consent. Following a HAM length examination, subjects were divided into a normal length of HAM group (NHG, n = 9) and a shortened length of HAM group (SHG, n = 14).

2. Active knee extension test

The active knee extension test was used to measure differences in HAM length, and as a criterion to divide the subjects into groups. Each subject lay in a supine position, with the pelvis fixed by a pelvic belt, and was instructed to bend the hip and knee joints by 90° while maintaining the ankle joints in a neutral position. The subject was then instructed to extend the knee joints slowly without extending the hip joints, and to stop when they felt the HAM begin to pull. The knee extension angle was measured using a goniometer. When the knee joint was bent to 90°, this angle was designated as 0° to facilitate measurement of the increase in angle during knee extension. Subjects found to have a knee flexion angle < 35° in the active knee extension test (Magee, 2013) were classified into the SHG.

3. Electromyography

The muscle activities of the ES, rectus abdominis (RA), EO, and HAM muscles were measured using a surface electromyography (4D-SES, RELIVE, Korea). The sampling rate was set to 1,024 Hz, the band-pass filter to 10–500 Hz, and the notch filter to 60 Hz. The root mean square (RMS) was calculated at an epoch length of 50 ms. Electromyography (EMG) data were analyzed using the RELIVE EMG software (4D-SES, RELIVE, Korea). EMG data were normalized by conversion to % maximal voluntary isometric contraction (% MVIC). MVIC was measured by the manual muscle testing method (Mendell and Julaine, 1990). We used the average of the middle 3 s of data of the 5-s recording period (first and last 1 s were excluded) in the analysis.

4. Plank exercise

Plank exercise(PE) was performed using the following method: in the prone position, the subject was instructed to flexion shoulder and elbow to shoulder width, so that the shoulders and elbows were perpendicular and contacting the ground with the forearm, and then to fully extend the knees while maintaining neutral spinal position, and contacting the ground with the toes. The feet were constantly maintained at pelvic width (Schoenfeld et al., 2014). The subject was instructed to keep the head, back, and legs as straight as possible while maintaining the plank position. After a training session, the subject practiced until the plank posture became familiar, and then the PE was performed five times in total, holding the position for 10 s each time, with a 5-min rest between exercises. We used the average of the data obtained during the middle 6 s of the recording period (first and last 2 s excluded) for data analysis.

5. Statistical analysis

All statistical analyses were performed using SPSS software (ver. 20.0; SPSS Inc., Chicago, IL, USA). Independent t-tests were performed to determine differences in HAM, ES, RA, and EO muscle activities between groups. Significance was determined at α=.05.

Ⅲ. Results

The results showed that ES, RA, and EO muscle activities were larger in the NHG than in the SHG; however, no significant differences were detected. HAM muscle activity was significantly higher in the SHG than in the NHG ($p<.05$)<Table 1>.

Table 1. Comparisons of trunk muscles and hamstring muscle activation between normal length of hamstring group and shortened length of hamstring group

	NHG (N=9)	SHG (N=14)
RA	163.77 ± 130.98[a]	139.04 ± 90.66
EO	87.21 ± 29.13	83.85 ± 29.32
ES	24.76 ± 16.85	18.54 ± 13.53
HAM[*]	9.65 ± 2.14	11.52 ± 1.17

[a]mean±SD, $^{*}p<.05$, RA=rectus abdominis; EO=external oblique; ES=erector spinae; HAM=hamstring; NHG=normal length of hamstring group; SHG=shortened length of hamstring group.

Ⅳ. Discussion

PE is a commonly used core exercise; various studies of PE have been conducted, particularly comparing the effects of diverse PE methods on muscle activation. Lee et al(2016) studied ES, EO, and RA muscle activities during PE performed on three different surfaces to determine the surface that induced the highest muscle activity, and suggested that this approach should be used to recommend specific PEs to professional athletes and patients with weakened abdominal muscles. Kang et al(2016) investigated changes in the thickness and balance ability of the TrA, IO, and EO muscles when PE was performed on various supporting surfaces over a 4-week period, to determine the most effective PE method for healthy subjects. The present study showed that core muscle activity differed between subjects with normal and shortened HAMs, although these differences were not significant. This finding suggests that the effects of the same PE can vary according to characteristics of subject such as muscle tightness and shortness, asymmetrical right and left muscle length.

HAM injury is the most common injury in athletes, and can be caused by various factors including weakened knee flexors (Ekstrand et al., 2012), muscle imbalance between the quadriceps femoris and HAM muscles (Fousekis et al., 2011), and performing exercise while the long head of the biceps femoris (a HAM muscle) is shortened (Timmins, et al., 2016). When there is an imbalance in the muscles around the femur, the strong HAM muscle continues to activate; this results in a more severe imbalance between the muscles, in turn inducing HAM injuries and low back pain, which are related to patellofemoral pain syndrome (Lardner et al., 2010). In this study, HAM activity tended to increase in an effort to maintain hip joint extension during PE, while knee extension posture increased the passive tension in the HAM, further stimulating its activity. Therefore, if a person with a shortened HAM performs repetitive PE, HAM stimulation will increase to cause hyperactivity, which may negatively impact the lower back and knee joints.

Ⅴ. Conclusion

When PE is performed by a subject with a shortened HAM, it lead to overactivate the HAM. Due to the negative effects of an overactive HAM on the lower back and knee joints, it is recommended that people with a shortened HAM perform sufficient HAM stretching before PE or perform alternative exercises to strengthen the core muscles.

Reference

An C. The effects of hamstring stretching exercise on angle of lumbar flexion and pain reduction with chronic low back patients. J Kor Phy Ther 2005;17(4);559-67.

Cosio-Lima LM, Reynolds KL, Winter C, et al. Effects of physioball and conventional floor exercises on early phase adaptations in back and abdominal core stability and balance in women. J Strength Cond Res 2003;17(4);721-5.

de Marche Baldon R, Lobato DFM, Carvalho LP et al. Effect of functional stabilization training on lower limb biomechanics in women. Med Sci Sports Exer 2012;44(1);135-45.

Duncan M. Muscle activity of the upper and lower rectus abdominis during exercises performed on and off a swiss ball. J Bodyw Mov Ther 2009;13(4);364-7.

Ekstrand J, Healy JC, Waldén M, et al. Hamstring muscle injuries in professional football: The correlation of MRI findings with return to play. Br J Sports Med 2012;46(2);112-7.

Fousekis K, Tsepis E, Poulmedis P, et al. Intrinsic risk factors of non-contact quadriceps and hamstring strains in soccer: A prospective study of 100 professional players. Br J Sports Med 2011;45(9);709-14.

Han WJ, Son KH. The Effect of Unstable Support Surface Plank Exercise on Flexibility, Abdominal Muscle Thickness and Pain in Chronic Low Back Pain. Kor Phy 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 Kor Phy Ther 2016;28(5);264-8.

Kim GC, Hwang BG. Kinetic Analysis on the Lumbar at the Trunk Flexion according to the Degree of Hamstring Flexibility of Healthy Adult. J Kor Soc Phy Med 2012;7(4);501-7.

Kwon BY. Effects of core stability and mobility training with aero equipment on biomechanical balance, posture, strength and agility for rhythmic gymnasts. [dissertation] Ewha Womans University; 2008.

Lardner PF, Frank CC, Page P. Assessment and treatment of muscle imbalance the janda approach; 2010.

Lee et al. Comparison of three different surface plank exercises on core muscle activity. Phy Ther Rehab Sci 2016;5(1);29-33.

Magee DJ. Orthopedic Physical Assessment. Elsevier Health Sciences; 2013.

Mendell JR, Florence J. Manual muscle testing. Muscle Nerve: Official Journal of the American Association of Electrodiagnostic Medicine 1990;13(S1);S16-20.

Oh YT, Effect of hold-relax technique for college students with hamstring shortening. J Kor Soc Phy Med 2013;8(3):433-41.

Park M. Changes of quadriceps and hamstring strength ratio in women of different ages. Phy Ther Kor 2006;13(3);75-83.

Park YA, Kim EJ, Cha HY, et al. Effects of various plank exercises on activation of hamstring muscle. Kor Phy Ther Sci 2020;27(1):51-5.

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.

Snarr RL, Esco MR. Electromyographical comparison of plank variations performed with and without instability devices. J Strength Cond Res 2014;28(11);3298-305.

Timmins RG, Bourne MN, Shield AJ et al. Short biceps femoris fascicles and eccentric knee flexor weakness increase the risk of hamstring injury in elite football (soccer): A prospective cohort study. Br J Sports Med 2016;50(24);1524-35.

Yoon M, Choi H, Shin W. Effects of the abdominal drawing-in maneuver and the abdominal expansion maneuver on grip strength, balance and pulmonary function in stroke patients. J Kor Phy Ther 2015;27(3);147-53.