www.iaptr.org
J Int Acad Phys Ther Res 2020; 11(3): 2102~2106
https://doi.org/10.20540/JIAPTR.2020.11.3.2102
ISSN 2092-8475

The Effects of Static Hamstring Stretching on Hip Motion and Lumbo-Pelvic Kinematics

Background: Static hamstring stretching exercises have been widely used to improve flexibility of the hamstring muscles. However, few studies have examined the influence of standing static hamstring stretching (e.g., jack-knife stretching) on movements of the lumbopelvic-hip complex.
Objectives: To examine the short-term effects of jack-knife stretching on movements of the lumbopelvic-hip complex.
Design: Case series.
Methods: Fourteen participants with hamstring tightness (8 male, 6 female) were recruited. Participants performed jack-knife stretching for 150 s. Before and after stretching, participants performed the finger-to-floor distance (FFD), sit and reach (SRT), active knee extension (AKE), passive straight leg raising (PSLA), and active straight leg raising (ASLR) tests as well as pelvic tilt while standing to identify the effects of stretching.
Results: There were significant improvements in the FFD, SRT, AKE, PSLA, and ASLR tests after stretching. However, pelvic tilt angle while standing did not significantly change.
Conclusion: Jack-knife stretching can be a useful exercise to improve flexibility of the hamstring muscles, but not pelvic alignment while standing.

Keywords: *Hamstring tightness; Kinematics; Stretching*

Jaeseop Oh, PT, Prof., PhD[a], Minhyeok Kang, PT, Prof., PhD[b]

[a]Department of Physical Therapy, Inje University, Gimhae, Republic of Korea; [b]Department of Physical Therapy, Catholic University of Pusan, Busan, Republic of Korea

Received : 07 July 2020
Revised : 03 August 2020
Accepted : 10 August 2020

Address for correspondence
Minhyeok Kang, PT, PhD
Department of Physical Therapy, College of Health Sciences, Catholic University of Pusan, 57, Oryundae-ro, Geumjeong-gu, Busan, Republic of Korea
Tel: 82-51-510-0551
E-mail: kmhyuk01@gamil.com

INTRODUCTION

Excessive lumbar flexion has been suggested to be a risk factor for lower back pain.[1,2] Tightness of the hamstring muscles, which reach from the pelvis to the knee, can lead to posterior pelvic tilt, which can in turn result in lumbar flexion through the lumbopelvic kinematic link.[3] Thus, such tightness can cause lower back pain due to the resultant excessive lumbar flexion, which is a risk factor for such pain.[1-3] Two types of hamstring stretching exercises are frequently performed in clinics: dynamic and static.[4-7] Previous studies have reported no significant difference in hamstring flexibility outcomes between these.[7-10] Compared to general static stretching exercises performed in a supine or sitting position, a previous study suggested that static hamstring stretching be performed in a standing position.[11] In that study, after athletes practiced static hamstring stretching while standing with the knees extended and the chest against the thighs (termed jack-knife stretching) for 4 weeks, the finger-to-floor distance (FFD) decreased by as much as 17.7 cm.[11] Although jack-knife stretching is considered an effective hamstring stretching technique, that study measured only FFD and not other variables related to hamstring flexibility.

To verify the effects of hamstring stretching, active and passive straight leg raising (ASLR and PSLA) and active knee extension (AKE) tests, along with measures of lumbar flexion, have also been performed in the previous studies.[4,12,13] Given that hamstring tightness can be a risk factor for lower back pain,[1-3] a study is needed to examine how hamstring stretching changes lumbopelvic and lower extremity kinematics by altering hamstring tightness. In addition, the effects

of jack-knife stretching maneuver were reported only in the previous study by Sairyo et al.[11] Thus, the effects of jack-knife stretching maneuver on other variables not measured in the previous study should be identified before comparing effects of jack-knife stretching maneuver with other hamstring stretching techniques.

Thus, the aim of this study was to investigate how static hamstring stretching using the jack-knife stretching maneuver influences lower extremity movements and lumbopelvic kinematics. Given what is known about jack-knife stretching,[11] this technique would improve lower extremity movement and lumbopelvic kinematics.

SUBJECTS AND METHODS

Subjects

For this study, 14 adults (8 males and 6 females, mean age: 21.43±2.31 years, height: 169.00±8.00 cm, body weight: 71.00±13.85 kg) with bilateral hamstring tightness were recruited. All subjects showed limited active knee extension (<160°), as suggested in a previous study.[4,14] Exclusion criteria were a history of lower back pain in the past 6 months, knee or lumbar spine surgery, and diagnosis of spinal deformity or lower extremity injuries. All subjects provided informed consent before participating in this study. The Institutional Research Review Committee of Inje University approved this study (INJE 2019-06-009-001).

Outcome Measures

Finger-to-floor distance test

To perform the FFD test, 3-axis gyroscope sensors (4D-MT motions sensor, Relive Co., Ltd., Gimhae, Republic of Korea) were attached between first and second lumbar spinous processes and between the posterior superior iliac spines of the subject in a standing position.[15] Subjects were asked to bend forward as far as possible with knees extended. An examiner measured the distance between the longest finger and the floor.[11,16] In this position, the lumbar flexion angle and pelvic anterior tilt angle were measured using the gyroscope sensors. Generally, a smaller value of FFD indicates greater hamstring flexibility.

Sit and reach test

The sit and reach test (SRT) was performed to examine hamstring flexibility. The subject sat with knees extended and feet fixed on the plate of the SRT instrument. Then subject was asked to bend forward, and an examiner measured the distance between plate of the SRT instrument and the longest finger.[13,17] Generally, a greater value of SRT indicates greater hamstring flexibility.

Active knee extension test

In a supine position with 90° hip flexion, subjects were asked to extend the knee as far as possible.[4] An examiner measured the knee extension angle using a smartphone application (Plaincode Software Solutions, Stephanskirchen, Germany). All measurements were performed on both sides. Generally, a greater value of AKE indicates greater hamstring flexibility.

Passive and active straight leg raising

To measure PSLR and ASLR, subjects were positioned in a supine position. For PSLR, an examiner flexed the subject's hip while maintaining knee extension. For ASLR, subjects were asked to actively flex the hip while maintaining knee extension.[12] An examiner measured the hip flexion angle using a smartphone application (Plaincode Software Solutions).[12] All measures were performed on both sides. Generally, a greater value of PSLR and ASLR indicates greater hamstring flexibility.

Pelvic tilt angle while standing

To measure the pelvic tilt angle, subjects were instructed to stand in a relaxed position. Then an examiner measured the left and right pelvic anterior tilt angles using a Palpation Meter (Performance Attainment Associates, St. Paul, MN, USA).[18]

Interventions

All subjects performed jack-knife stretching of the hamstring muscles. For this exercise, subjects were positioned in a squatting posture while grasping both ankles. Subjects were asked to extend the knees while pressing the chest against the thighs.[11] Subjects held the maximum knee extension position for 10 s and then returned to the start position. This procedure was repeated 15 times with 10 s rest periods between trials.

Study Procedures

All outcome variables were measured before performing jack-knife stretching, and then subjects

performed jack-knife stretching. Immediately after jack-knife stretching, all outcome variables were measured again. Measures of outcome variables were performed in a randomized order under the each measurement condition (e.g., pre- and post-stretching conditions).

Data and Statistical Analyses

Intra-rater reliability for all outcome measures was identified with intra-class correlation coefficients (ICC) using baseline data. High reliability was observed in all outcome variables (Table 1). All measurements were repeated three times with 30 s of rest period between trials, and the mean value of the three trials was used for data analyses using PASW Statistics 18 software (SPSS, Inc., Chicago, IL). Shapiro-Wilk test was used to verify the normal distribution of outcome variables. To identify the effects of jack-knife stretching on outcome variables, paired t-tests were performed. If outcome variables violated the normal distribution, they were analyzed using Wilcoxon signed rank test. The α-value was set at .05.

RESULTS

A significant decrease in FFD was found after jack-knife stretching (P=.011, Table 1). Furthermore, anterior pelvic tilt and lumbar flexion during the FFD test as well as SRT, AKE, PSLR, and ASLR showed significant increases after stretching (P<.05, Table 1). However, there was no significant change in pelvic tilt angle while standing after stretching (P>.05, Table 1).

DISCUSSION

Jack-knife stretching, a static hamstring stretching maneuver, was introduced to address hamstring tightness. A previous study used only the FFD test to identify the effects of jack-knife stretching.[11] Thus, the present study examined the influence of jack-knife stretching on several variables related to dynamic movements of the lower extremities.

Jack-knife static stretching improved outcome measures of hamstring flexibility including results on the FFD, SRST, AKE, PSLR, and ASLR tests (all P<.05). Our assessed maneuver was similar to most passive stretching maneuvers in terms of maintaining the end range of motion. However, the fact that active muscle contraction was required to maintain the end range during jack-knife stretching made it different from most such maneuvers.[19] Active static stretching maneuvers (i.e., jack-knife stretching) improve flexibility using reciprocal inhibition, unlike

Table 1. Outcome measures before and after stretching

Tests	Variables	Side	ICC	Pre-stretching	Post-stretching	*P*
FFD	Distance (cm)		.995	6.74 ± 12.65	0.41 ± 9.39	.011*
	Anterior pelvic tilt (°)		.987	61.74 ± 18.04	66.84 ± 16.43	.022*
	Lumbar flexion (°)		.984	96.57 ± 18.51	104.13 ± 14.16	.035*
SRT	Distance (cm)		.988	−0.17 ± 8.34	4.57 ± 7.11	.001*
AKE	Angle (°)	Right	.979	51.38 ± 10.36	56.38 ± 13.04	.007*
	Angle (°)	Left	.981	51.76 ± 10.75	59.36 ± 13.86	.003*
PSLR	Angle (°)	Right	.984	62.29 ± 8.93	67.21 ± 10.76	.002*
	Angle (°)	Left	.989	61.62 ± 8.99	66.95 ± 9.07	.001*
ASLR	Angle (°)	Right	.987	57.79 ± 13.02	69.12 ± 11.27	.001*
	Angle (°)	Left	.978	58.95 ± 11.21	69.19 ± 11.54	.001*
Pelvic tilt angle in standing	Angle (°)	Right	.990	7.00 ± 4.84	7.48 ± 5.41	.552
	Angle (°)	Left	.991	8.24 ± 4.93	8.36 ± 5.21	.842

*P<.05

Abbreviations: AKE, active knee extension; ASLR, active straight leg raising; FFD, finger to floor test; ICC, intra-class correlation coefficients; PSLR, passive straight leg raising; SRT, sit and reach test.

general passive static stretching.[20,21] It is theorized that reciprocal inhibition leads to relaxation of antagonist muscles by inhibitory interneurons when the agonist is activated.[21] According to this theory, active static stretching is more effective for improving hamstring flexibility compared to passive static stretching.[19,20] Thus, an active static stretching maneuver (i.e., jack-knife stretching) relaxed the hamstring muscle tension using reciprocal inhibition, which led to significant changes in outcome measures of hamstring flexibility.

After jack-knife stretching, anterior pelvic tilt and lumbar flexion during FFD were significantly increased. The increased anterior pelvic tilt may result from increased hamstring flexibility, because hamstring tightness restricts anterior pelvic tilt during forward bending.[2,3] In addition, the amount of change in lumbar flexion (7.56°) is similar to the amount of change in anterior pelvic tilt (5.10°) after stretching in the present study. Thus, increased lumbar flexion may be caused by changed anterior pelvic tilt rather than a direct change in lumbar movement by hamstring stretching.

Despite significant improvement in hamstring flexibility and dynamic movements of the lower extremities, standing pelvic alignment was not significantly changed after jack-knife stretching in this study ($P > .05$). These findings are similar to those of Bormann et al.[22] In that study, hamstring flexibility was significantly improved, whereas lumbar curvature while standing did not significantly change after 4 weeks of hamstring stretching in a sitting or standing position. Considering another previous study that showed no significant relationship between hamstring muscle length and lumbar lordosis,[23] it is likely that standing pelvic alignment may be influenced by multiple factors in addition to hamstring muscle length. However, we did not examine other factors (e.g., back muscle length, abdominal muscle length, and so forth) that might influence pelvic alignment. Therefore, future research needs to identify possible factors influencing standing pelvic alignment.

Several limitations of this study should be noted. First, subjects performed jack-knife stretching for only 1 day. The long-term effects should be evaluated in a future study. Second, direct measurements of hamstring flexibility, such as measuring changes in the myotendinous junction of the hamstring muscle, were not performed. To demonstrate the effects of jack-knife stretching on hamstring muscle morphology, such changes should be assessed directly. Lastly, we did not include control group that could compare effects of hamstring stretching techniques.

CONCLUSION

Static hamstring stretching using the jack-knife maneuver can improve hamstring flexibility. Thus, it can be a useful exercise in clinics for individuals with hamstring tightness.

CONFLICT OF INTERESTS

The author declares that there are no conflicts of interest.

REFERENCES

1. McGill SM. *Low Back Disorders: Evidence-Based Prevention and Rehabilitation*. 2nd ed. Champaign: Human Kinetics; 2007.
2. Sahrmann SA. *Diagnosis and Treatment of Movement Impairment Syndrome*. St. Louis: Mosby; 2002.
3. Neumann DA. *Kinesiology of the Musculoskeletal System: Foundations for Rehabilitation*. 3rd ed. St Louis: Elsevier; 2017.
4. Kang MH, Jung DH, An DH, Yoo WG, Oh JS. Acute effects of hamstring-stretching exercises on the kinematics of the lumbar spine and hip during stoop lifting. *J Back Musculoskelet Rehabil*. 2013;26(3):329-336.
5. Medeiros DM, Cini A, Sbruzzi G, Lima CS. Influence of static stretching on hamstring flexibility in healthy young adults: Systematic review and meta-analysis. *Physiother Theory Pract*. 2016;32(6):438-445.
6. Yıldırım MS, Ozyurek S, Tosun O, Uzer S, Gelecek N. Comparison of effects of static, proprioceptive neuromuscular facilitation and Mulligan stretching on hip flexion range of motion: a randomized controlled trial. *Biol Sport*. 2016;33(1):89-94.
7. Demoulin C, Wolfs S, Chevalier M, et al. A comparison of two stretching programs for hamstring muscles: A randomized controlled assessor-blinded study. *Physiother Theory Pract*. 2016;32(1):53-62.
8. Ahmed H, Iqbal A, Anwer S, Alghadir A. Effect of modified hold-relax stretching and static stretching on hamstring muscle flexibility. *J Phys Ther Sci*. 2015;27(2):535-538.

9. Lim KI, Nam HC, Jung KS. Effects on hamstring muscle extensibility, muscle activity, and balance of different stretching techniques. *J Phys Ther Sci.* 2014;26(2):209-213.
10. Puentedura EJ, Huijbregts PA, Celeste S, et al. Immediate effects of quantified hamstring stretching: hold-relax proprioceptive neuromuscular facilitation versus static stretching. *Phys Ther Sport.* 2011;12(3):122-126.
11. Sairyo K, Kawamura T, Mase Y, et al. Jack-knife stretching promotes flexibility of tight hamstrings after 4 weeks: a pilot study. *Eur J Orthop Surg Traumatol.* 2013;23(6):657-663.
12. Gunn LJ, Stewart JC, Morgan B, et al. Instrument-assisted soft tissue mobilization and proprioceptive neuromuscular facilitation techniques improve hamstring flexibility better than static stretching alone: a randomized clinical trial. *J Man Manip Ther.* 2019;27(1):15-23.
13. Han HI, Choi HS, Shin WS. Effects of hamstring stretch with pelvic control on pain and work ability in standing workers. *J Back Musculoskelet Rehabil.* 2016;29(4):865-871.
14. Spernoga SG, Uhl TL, Arnold BL, Gansneder BM. Duration of maintained hamstring flexibility after a one-time, modified hold-relax stretching protocol. *J Athl Train.* 2001;36(1):44-48.
15. Jung SH, Kwon OY, Yi CH, et al. Predictors of dysfunction and health-related quality of life in the flexion pattern subgroup of patients with chronic lower back pain: The STROBE study. *Medicine (Baltimore).* 2018;97(29):e11363.
16. Hasebe K, Okubo Y, Kaneoka K, Takada K, Suzuki D, Sairyo K. The effect of dynamic stretching on hamstrings flexibility with respect to the spino-pelvic rhythm. *J Med Invest.* 2016;63(1-2):85-90.
17. Ayala F, Sainz de Baranda P, De Ste Croix M, Santonja F. Reproducibility and criterion-related validity of the sit and reach test and toe touch test for estimating hamstring flexibility in recreationally active young adults. *Phys Ther Sport.* 2012;13(4):219-226.
18. Kang MH, Kim ER, Kim YG, Kim TH, Oh JS. The effects of lumbo-pelvic postural taping on gait parameters in patients with lumbar spinal stenosis. *Clin Biomech (Bristol, Avon).* 2013;28(9-10):956-960.
19. Meroni R, Cerri CG, Lanzarini C, et al. Comparison of active stretching technique and static stretching technique on hamstring flexibility. *Clin J Sport Med.* 2010;20(1):8-14.
20. White SG, Sahrmann SA. *A Movement System Balance Approach to Management of Musculoskeletal Pain.* In: Grant R. Physical Therapy of The Cervical and Thoracic Spine. New York: Churchill Livingstone Inc; 1994:339-357.
21. Kisner C, Colby LA. Therapeutic *Exercise: Foundations and Techniques.* 6th ed. Philadelphia: FA Davis Company; 2012.
22. Borman NP, Trudelle-Jackson E, Smith SS. Effect of stretch positions on hamstring muscle length, lumbar flexion range of motion, and lumbar curvature in healthy adults. *Physiother Theory Pract.* 2011;27(2):146-154.
23. Nourbakhsh MR, Arab AM. Relationship between mechanical factors and incidence of low back pain. *J Orthop Sports Phys Ther.* 2002;32(9):447-460.