Effect of High-frequency Diathermy on Hamstring Tightness

Ye Jin Kim¹, BPT, PT, Joo-Hee Park², PhD, PT, Ji-hyun Kim¹, BPT, PT, Gyeong Ah Moon¹, BPT, PT, Hye-Seon Jeon², PhD, PT

¹Department of Physical Therapy, The Graduate School, Yonsei University, ²Department of Physical Therapy, College of Health Science, Yonsei University, Wonju, Korea

Article Info

Received January 14, 2021

Revised January 25, 2021

Accepted January 28, 2021

Corresponding Author

Hye-Seon Jeon

E-mail: hyeseonj@yonsei.ac.kr

<https://orcid.org/0000-0003-3986-2030>

Key Words

Diathermy

Hamstring muscles

Muscle tonus

Physical therapy modalities

Background: The hamstring is a muscle that crosses two joints, that is the hip and knee, and its flexibility is an important indicator of physical health in its role in many activities of daily living such as sitting, walking, and running. Limited range of motion (ROM) due to hamstring tightness is strongly related to back pain and malfunction of the hip joint. High-frequency diathermy (HFD) therapy is known to be effective in relaxing the muscle and increasing ROM.

Objects: To investigate the effects of HFD on active knee extension ROM and hamstring tone and stiffness in participants with hamstring tightness.

Methods: Twenty-four participants with hamstring tightness were recruited, and the operational definition of hamstring tightness in this study was active knee extension ROM of below 160° at 90° hip flexion in the supine position. HFD was applied to the hamstring for 15 minutes using the WINBACK device. All participants were examined before and after the intervention, and the results were analyzed using a paired t-test. The outcome measures included knee extension ROM, the viscoelastic property of the hamstring, and peak torque for passive knee extension.

Results: The active knee extension ROM significantly increased from $138.8^\circ \pm 9.9^\circ$ (mean $\pm$ standard deviation) to $143.9^\circ \pm 10.4^\circ$ after the intervention ($p < 0.05$), while viscoelastic property of the hamstring significantly decreased ($p < 0.05$). Also, the peak torque for knee extension significantly decreased ($p < 0.05$).

Conclusion: Application of HFD for 15 minutes to tight hamstrings immediately improves the active ROM and reduces the tone, stiffness, and elasticity of the muscle. However, further experiments are required to examine the long-term effects of HFD on hamstring tightness including pain reduction, postural improvement around the pelvis and lower extremities, and enhanced functional movement.

INTRODUCTION

The hamstring functions as both the hip extensor and knee flexor. Because it crosses both the hip and knee, the length of the hamstring affects not only the range of motion (ROM) of hip flexion and knee extension; but also the posture of the pelvis and spine [1,2]. Hamstring tightness is a major cause of back injury and dysfunction [3,4]. In particular, forward bending motion is affected by the length of hamstring, and hamstring tightness increases the risk of spinal injury due to mechanical stress [5]. Previous studies have reported that maintaining proper hamstring length prevents excessive flexion of the low back during forward bending, which reduces the

risk of injury by reducing anterior shearing forces of the spine [6]. In addition, it can lead to dysfunctions, such as poor posture and abnormal walking stance [7]. According to Wong and Lee [8], because the hamstring is a major dynamic muscle in the pelvic area, tightness of this muscle reduces pelvic anterior tilting, limits hip joint movements, and causes pain. Ultimately, structural and functional changes in the hamstring affect activities of daily living, such as walking and postural control. Therefore, hamstring flexibility is an important contributor to physical health, and plays a role in many activities of daily living such as sitting, walking, and running [9].

Treating muscle tightness is essential for maintaining and improving the posture and preventing injuries during daily life

activities or exercise [10]. Various stretching techniques, physical agents and medications have been studied as interventions for muscle tightness. Conventionally, manual approaches such as hold-relax, stretching, and soft tissue mobilization have been commonly used to improve hamstring tightness, but the outcomes have been inconsistent. Moreover, manual techniques are physically demanding and can cause musculoskeletal impairments in therapists who apply these techniques. In addition, the most commonly used superficial heat therapy merely heat the skin and subcutaneous tissue to increase blood circulation, but it does not affect the deep tissues. Thus, diathermy therapy is used to relax the muscles by transmitting heat to the muscles [11]. High-frequency diathermy (HFD) therapy, produces heat through molecular vibrations in deep tissues [12]. Previous studies have shown that the application of HFD increase blood circulation and tissue flexibility, resulting in muscle relaxation [11,13]. HFD also increases the local tissue temperature to 40°C–45°C, thus increasing the pain threshold, reducing pain and enabling maximum stretch without damage [14].

Traditional HFD devices, however, have limitations in their application as the treatment electrodes are large and fixed. The WINBACK device (WINBACK 3SE, Villeneuve Loubet, France) is convenient to use as it allows therapists to use their hands and move the electrodes while applying HFD [15]. The device uses the transfer electrode capacitive and resistive (TECAR) technique, which operates within the long-wave radio frequency range at 0.5 MHz, and can apply both capacitive energy transfer (CET) with shallow penetration and resistive energy transfer (RET) with deep penetration depths. CET is effective in the treatment of soft tissue injuries because it uses coated electrodes to transmit heat quickly to the skin and superficial muscles, while RET uses uncoated electrodes, so it can gradually transmit heat to deep tissues, making it effective in the treatment of hard tissues such as tendons and joints.

Previous studies have shown that WINBACK increased the

length of the shortened gastrocnemius (GCM) and improved back pain [16,17]. However, no previous studies have been conducted on the relaxation effect of HFD on hamstring tightness. Therefore, the purpose of this study was to investigate the effects of HFD on the active knee extension ROM and hamstring tone and stiffness in participants with hamstring tightness.

MATERIALS AND METHODS

1. Participants

Twenty-four participants with hamstring tightness less than 160° in the active knee extension test volunteered for this study. The mean age was 25.9 ± 2.3 years. The exclusion criteria were (1) neuromotor or musculoskeletal impairments, (2) history of surgery in the lower extremities, (3) decreased temperature and pain sense and a metal insert in the HFD therapy area, and (4) difficulty in expressing thermal sense. All participants read a written explanation about the study and signed an informed consent form approved by Yonsei University Mirae Campus Institutional Review Board (approval no. 1041849-202008-BM-095-02). The demographic data of the participants are presented in Table 1.

2. Intervention

In this study, HFD was applied to the hamstring using the TECAR technique with the WINBACK device (Figure 1). In particular, the TECAR technique involves attaching a fixed

Figure 1. WINBACK 3SE device.

Table 1. General characteristics of the participants (N = 24)

Variables	Data
Age (y)	25.9 ± 2.3
Height (cm)	170.3 ± 9.5
Weight (kg)	73.9 ± 14.4
Body mass index (kg/m ²)	25.3 ± 3.8
Active knee extension range of motion (°)	138.8 ± 9.9

Values are presented as mean ± standard deviation.

electrode to the participant's body and applying a mobile electrode to the treatment area it allows therapists' to simultaneously use the device and their hands. To apply TECAR therapy to the hamstring muscles, the fixed electrode was applied to the quadriceps muscle, and the active electrode was applied to the hamstring with the participant in the prone position (Figure 2). The intervention was conducted for 15 minutes; the RET mode was applied for 10 minutes after 5 minutes of CET mode application. The current intensity was set to a level that the participants found comfortable and warm.

3. Outcome Measures

The Active knee extension ROM, peak torque for passive knee extension, and muscle tone related variables were measured before and after 15 minutes of TECAR therapy.

1) Active knee extension ROM test

The active knee extension ROM test was conducted to measure the hamstring length before and after the intervention, and the knee joint extension angle was measured using a universal goniometer. The test started with a 90° flexion of the hip and knee joints, with the ankle in the neutral position and the participant in the supine position. The cross-bar was used to maintain 90° flexion of the hip joint, and the angle was measured with the knee in full extension. During the test, the pelvis and opposite thigh were secured with straps to maintain lordotic curve of lumbar and prevent compensatory movement (Figure 3). The stable arm of the goniometer was positioned laterally near the epicondyle of the femur, and the moving arm was positioned over the line drawn from the fibular head to

the lateral malleolus.

2) Peak torque for passive knee extension

The Biodex System Isokinetic Dynamometer (Biodex Medical, Shirley, NY, USA) was used to assess the peak torque for passive knee extension. The participant sat on the Biodex dynamometer chair, and their trunk, pelvis, and thigh were secured with straps to minimize compensation movement. After aligning the dynamometer axis to the participant's knee joint axis, the calf was fixed with straps (Figure 4). The dynamometer was set to repeat five times at an angular velocity of 5°/s in passive mode, and the average value was obtained by measuring it three times. The knee extension angle was set to the full ROM of the participants.

Figure 3. Active knee extension ROM test. ROM, range of motion.

Figure 2. TECAR therapy to the hamstring. TECAR, transfer electrode capacitive and resistive.

Figure 4. Biodex system isokinetic dynamometer.

Figure 5. Description of the MyotonPRO structure.

3) Viscoelastic property of the hamstring

MyotonPRO (Myoton AS, Tallinn, Estonia) was used to measure the viscoelastic properties of the muscle (Figure 5). The MyotonPRO is a device that can measure muscle tone(F), dynamic stiffness(S), elasticity(D), relaxation time(R), and creep(C); it has high reliability in evaluating muscle characteristics [18]. At the beginning of the assessment, the participants rested in the prone position without voluntary contraction of the muscles. The data were collected from the semitendinosus and biceps femoris muscles, and each muscle belly was marked using a pen so that the same point could be measured. The device was placed perpendicular to the skin surface at the marked point and pressed until the measuring range (3 mm) marked on the probe was reached. The pre-compression at this time was 0.18 N and the device automatically made five

Table 2. Active knee extension ROM

Variable	Pre-test	Post-test	p-value
ROM (°)	138.8 ± 9.9	143.9 ± 10.4	0.00

Values are presented as mean ± standard deviation. ROM, range of motion.

Table 3. Peak torque for passive knee extension

Variable	Pre-test	Post-test	p-value
Peak torque (N/m)	20.3 ± 4.0	19.3 ± 3.5	0.03

Values are presented as mean ± standard deviation.

taps when placed within the measuring range. The impulse force during tapping was 0.4 N, and impulse time was 15 ms. In this study, three variables (muscle tone, stiffness, and elasticity) were measured and analyzed. According to the manufacturer's manual, muscle tone refers to the oscillation frequency of a muscle in its resting state without any voluntary contraction, and dynamic stiffness refers to the biomechanical characteristic of a muscle that allows it to resist external forces that deform its initial shape, and elasticity and the ability of the muscle to recover its initial shape after removal of the external force [19].

4. Statistical Analysis

The collected data were statistically analyzed using Windows SPSS version 24.0 (IBM Co., Armonk, NY, USA). A paired t-test was used to compare the means of the dependent variables before and after the intervention; the significance level was set to 0.05.

RESULTS

1. Active Knee Extension ROM

All participants demonstrated significant improvement in the active knee extension ROM after the application of HFD ($p < 0.05$) (Table 2).

2. Peak Torque for Passive Knee Extension

The peak torque decreased significantly after the application of HFD ($p < 0.05$) (Table 3).

3. Viscoelastic Property Variables of the Hamstring

The viscoelastic property variables of muscle tone, stiffness, and elasticity obtained from the MyotonPRO had significantly

decreased ($p < 0.05$) (Table 4, Figure 6).

DISCUSSION

The present study examined the clinical effects of applying HFD using the WINBACK device, on participants with hamstring tightness. With 15 minutes of HFD application to the hamstring, the active knee extension ROM increased, and the peak torque for passive knee extension, muscle tone, stiffness, and elasticity decreased. The Decrease in muscle tone, stiffness, elasticity, and peak torque indicates the release of hamstring muscle tightness, resulting in an increase in knee extension ROM.

Hamstring tightness is known to result in reduced range of motion and increased viscoelasticity and contractility of soft tissues [20]. The decrease in peak torque in this study indicates that after HFD application, subjects were able to move from specific torque level to a wider range of motion, and this change in torque can be attributed to increased local temperature and changes in muscle viscoelasticity due to HFD, resulting in muscle relaxation [21,22]. The decrease in viscoelasticity property variables measured by the MyotonPRO also seems to be due to tissue changes in the hamstring caused by HFD. In

this study, muscle tone, stiffness, and elasticity were reduced, which was consistent with previous study of HFD in GCM [16]. Yeatman et al. [23] reported that temperature and muscle elasticity were inversely proportional to each other, and the decrease in muscle elasticity in the study was attributed to increased deep heat due to HFD.

It is known that high-frequency current passing through human tissue is converted to thermal energy, resulting in deep-tissue heat and pain reduction, microcirculation, and vasodilatation. HFD is beneficial for the release of tight muscles, ligaments, and tendons [24]. Fifteen minutes of HFD application increased the local temperature of the body by 3°C – 5°C , and the increase in temperature was maintained for 3–4 hours after treatment [25]. Lehmann stated that optimal functional recovery of the tissue and maximum stretching can be achieved without tissue damage when the local temperature of the connective tissue is 40°C – 50°C [26]. Therefore, HFD is an effective intervention to maximize the effectiveness of muscle stretching. Therefore, future studies propose to confirm the effectiveness of applying HFD and muscle stretching simultaneously.

Because this study only investigated the short-term effects of HFD without a control group, experiments on the long-term effectiveness of HFD with a control group must be considered

Table 4. Viscoelastic property of hamstrings

Muscle	Variables	Pre-test	Post-test	p-value
Biceps femoris	Tone (Hz)	14.4 ± 1.0	13.9 ± 1.0	0.00
	Stiffness (N/m)	244.8 ± 28.6	230.6 ± 29.2	0.00
	Elasticity	1.1 ± 0.1	1.0 ± 0.1	0.00
Semitendinosus	Tone (Hz)	14.7 ± 1.4	14.0 ± 1.4	0.00
	Stiffness (N/m)	247.4 ± 34.2	231.7 ± 34.3	0.00
	Elasticity	1.1 ± 0.1	1.0 ± 0.1	0.00

Values are presented as mean $\pm$ standard deviation.

Figure 6. Viscoelastic property of hamstring. ST: semitendinosus; BF: biceps femoris; * $p < 0.05$.

in future studies. Furthermore, future studies need to include outcome measures to examine the dynamic functional changes after HFD application to the hamstring, such as jumping and running.

CONCLUSIONS

Our findings provide evidence that applying HFD for 15 minutes to tight hamstrings immediately improves the active knee extension ROM and reduces the peak torque, tone, stiffness, and elasticity of the hamstring. However, further experiments are required to examine the long-term effects of HFD on hamstring tightness, including possible pain reduction, postural improvement around the pelvis and lower extremities, and enhanced functional movement.

ACKNOWLEDGEMENTS

This study was supported by the “Brain Korea 21 FOUR Project”, the Korean Research Foundation for Department of Physical Therapy in the Graduate School of Yonsei University.

CONFLICTS OF INTEREST

No potential conflict of interest relevant to this article was reported.

AUTHOR CONTRIBUTIONS

Conceptualization: YJK, JHP, HSJ. Data curation: YJK, GAM, JK, JHP. Formal analysis: YJK, GAM, JK, JHP, HSJ. Investigation: YJK, GAM, JK, JHP. Methodology: YJK, GAM, JK, JHP, HSJ. Project administration: YJK, JHP, HSJ. Resources: YJK, GAM, JK, JHP. Supervision: YJK, GAM, JK, JHP, HSJ. Validation: YJK, HSJ. Visualization: YJK. Writing – original draft: YJK, HSJ. Writing – review & editing: YJK, HSJ.

ORCID

Ye Jin Kim, <https://orcid.org/0000-0003-0802-6195>

Joo-Hee Park, <https://orcid.org/0000-0001-9545-1362>

Ji-hyun Kim, <https://orcid.org/0000-0003-2701-4317>

Gyeong Ah Moon, <https://orcid.org/0000-0001-7906-811X>

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