J. Phys. Ther. Sci. 33: 912–916, 2021

The Journal of Physical Therapy Science

Original Article

Immediate effects of elongation training using an elastic band on the hip abductor muscles

Ryo Miyachi, RPT, PhD[1)*], Shun Sawai, RPT[2, 3)], Kazuki Maeta, RPT[4)], Junya Miyazaki, RPT, PhD[3)]

[1)] *Faculty of Health and Medical Sciences, Hokuriku University: 1-1 Taiyogaoka, Kanazawa, Ishikawa 920-1180, Japan*
[2)] *Department of Rehabilitation, Ikuseikai, Kyoto Kuno Hospital, Japan*
[3)] *Department of Physical Therapy, Faculty of Health Science, Kyoto Tachibana University, Japan*
[4)] *Department of Rehabilitation, Saiseikai Kyotohu Hospital, Japan*

Abstract. [Purpose] This study investigated the effects of elongation training on the hip abductor muscles in comparison with the effects of general hip abductor training. [Participants and Methods] This study included 39 healthy male university students. The participants were divided into elongation training and general-weighted hip abduction training groups. An elastic band was used for elongation training, and hip abduction exercises were performed with instructions to extend the foot as far as possible to stretch the band. Measurements were taken before and after training, and the surface electromyographic data of the gluteus medius and the tensor fasciae latae were measured during isometric contraction of the hip abductor muscles. The surface electromyogram data were used to calculate integral values and median power frequencies to compare the effects of training. [Results] In comparison with general hip abductor training, elongation training yielded a larger change in the ratio of muscle integral values (gluteus medius/tensor fasciae latae). [Conclusion] Elongation training of the hip abductor muscles was more useful than general training in increasing the activity of the gluteus medius while suppressing the activity of the tensor fasciae latae.

Key words: Hip abductor muscle, Electromyogram, Training

(This article was submitted Aug. 10, 2021, and was accepted Sep. 20, 2021)

INTRODUCTION

The hip joint is located near the center of gravity of the body. This important joint serves as a starting point for postural adjustment and movement. Among the many muscles related to the hip joint, the hip abductor muscles perform not only simple hip abduction movements such as moving the lower limb outward from the body but also pelvic control in the weight-bearing position and deflection control of the femoral head in the acetabulum. They are also involved in the control of sagittal, horizontal, and frontal plane movements[1–3)]. Patients with osteoarthritis of the hip have decreased muscle mass and fatty infiltration of the hip abductor muscles, which are associated with decreased walking ability[4)]. The hip abductor muscles are also associated with pathologies in areas other than the hip joint, such as iliotibial band syndrome[5, 6)], low back pain[7)], patellofemoral pain syndrome[8)], and ankle instability[9)]. Thus, the hip abductor muscles are often the target of training. Many training methods for the hip abductor muscles have been developed and validated, including clamshell exercises, hip abduction exercises performed while lying on the side, single-leg squats, and single-leg deadlifts. Some of these methods only increase the muscle activity of the hip abductor muscles, while others focus on their relationship with other muscle groups to specifically activate the hip abductor muscles; moreover, other training methods have been used with various

*Corresponding author. Ryo Miyachi (E-mail: ry_miyachi@hokuriku-u.ac.jp)

perspectives[10–12]. However, when training the hip abductor muscles, compensatory lumbar side bending (pelvic elevation) and hip flexion often occur, making it difficult for clinicians to obtain sufficient hip abductor training effects. Miyachi et al.[13] proposed increasing hip abductor muscles activity by suppressing the erector spinae through pelvic depression on the training side when training the hip abductor muscles. Therefore, training the hip abductor muscles requires development of methods to increase hip abductor muscle activity. Elongation training (ELT) is a training method that uses elastic bands that stretch well and is performed by moving the limbs and trunk in the longitudinal direction as if stretching the elastic bands[14]. When training the hip abductor muscles in ELT, the lower limb is moved to elongate the band attached to the foot distally. The hip is abducted while maintaining this position. Hip abductor training with ELT presumably suppresses the lumbar erector spinae by pelvic depression. In addition, the lower limb is also moved as far as possible distally to stretch the band, which inevitably results in the lower limb joint being in the neutral position, making it difficult to move in the sagittal plane. Therefore, while ELT may be used to efficiently train the hip abductor muscles, its effectiveness has not been fully verified.

Therefore, the purpose of the present study was to verify the effect of hip abductor training with ELT on the hip abductor muscles compared with general hip abductor training to suggest an efficient training method for the hip abductor muscles.

PARTICIPANTS AND METHODS

The participants included 39 healthy male university students (20.0 ± 0.8 years, 171.3 ± 5.6 cm, 64.5 ± 6.9 kg). The inclusion criteria were: no history of orthopedic disease or surgery of the lower limbs or spine, no pain affecting daily life, and no typical physical dysfunction such as paralysis or arthropathy. Before obtaining written consent, the participants were informed orally and in writing of the study purpose and content, assured that the data obtained would not be used for any purpose other than the study, and that their personal information would be held confidential. This study received approval from the Research Ethics Committee of Kyoto Tachibana University (Approval No.: 19-29).

The participants were randomly assigned to two groups: one that received hip abductor training with ELT (ELTG; n=20) and the other that received general hip abductor training with a weight band (GTG; n=19). Randomization was performed using a random number table in Microsoft Excel. Surface electromyography (EMG) data and maximal muscle strength were measured before and after training in both groups. All measurements and training were performed on the right leg. The training was performed individually, and the participants did not share information about their training with each other, thus making it impossible to know about the training of others.

The ELTG used a special elastic band (Elongation Band, ELT Health Promotion Laboratory Inc., Otsu, Japan) for training (Fig. 1A). Each participant was positioned in the left lower side-lying position, with the upper limbs in front of the chest in the left hip flexion position and the right hip neutral position of flexion/extension and rotation. An elastic band was attached to the right foot. The right foot was then moved as far as possible to the caudal side with the instruction, "Extend the foot as far as possible to stretch the band". The right leg was elevated and held with 0° of hip abduction/adduction to produce an isometric contraction of the hip abductor muscles. A total of five sets of 10 s of isometric contractions and 10 s of rest of the hip abductor muscles were performed. The GTG included frequent exercises with weighted bands used in clinical practice. In the GTG, as in the ELTG, a weight band was attached to the right ankle joint with the participants in the left lower side-lying position, with the upper limbs in front of the chest in the left hip flexion position and the right hip neutral position of flexion/extension and rotation. The lower limb was then raised and held at 0° of hip abduction/adduction to perform isometric contraction of the hip abductor muscles (Fig. 1B). The load of the weights was set by evaluating the estimated maximum load of the participants in advance and calculating the maximum load that could be trained in 10 s[15]. As in ELTG, the training comprised one set of 10 s of isometric contraction of the hip abductor muscles, followed by 10 s of rest, for a total of five sets.

Regarding the measurements before and after training, muscle torque was measured using a hand-held dynamometer (μTas F-1, Anima Co., Ltd., Tokyo, Japan) as an index of maximum muscle strength. The measurements were performed with the participants lying on their lower left side with right hip flexion/extension, abduction/adduction, and rotation at 0°. The sensor pad was placed on the distal lateral thigh and fixed with a belt to prevent the lower limb from moving from that position. In this position, the right hip abductor muscle was maximally contracted and the muscle torque was measured.

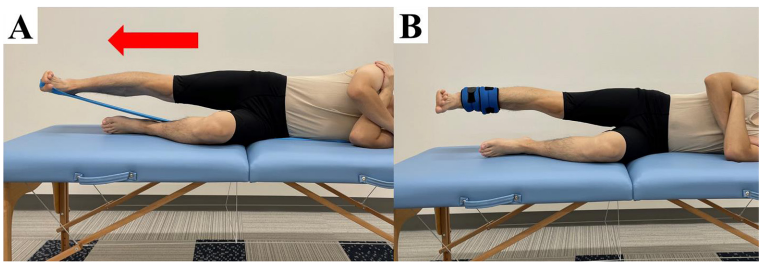

Fig. 1. Training methods. A: Hip abductor training with elongation training. B: General hip abduction training with a weight band.

A surface electromyography system (multichannel telemeter system WEB-1000, Nihon Kohden, Tokyo, Japan) was used to obtain EMG data as an index of hip abductor muscle activity. The sampling frequency was 1,000 Hz, and telemeter electrodes (Nihon Kohden, Tokyo, Japan) were placed on the right gluteus medius (GM) and tensor fasciae latae (TFL) using a bipolar derivation method. The electrodes were placed as described by Cram et al.[16], with the GM in the proximal third between the iliac crest and the greater trochanter and the TFL approximately 2 cm below the superior anterior iliac spine. After electrode placement, muscle activity was checked by performing hip abduction to determine if the electrodes were placed properly. For measurement, the participants were immobilized while lying on their lower left side with the right leg at 0° hip flexion/extension, abduction/adduction, and rotation and were asked to perform isometric hip abduction at maximum contraction for 10 s. The raw EMG data were band-pass filtered from 10 to 500 Hz to reduce movement artifacts and high-frequency noise before performing full-wave rectification. Five seconds of integrated electromyogram (IEMG) were calculated from 10 s of EMG data, excluding 2.5 s before and after. Frequency analysis was performed by fast Fourier transform to calculate the median power frequency (MF). To examine the training-induced changes in IEMG, the ratio of pre- to post-training (IEMG change; post/pre) was calculated. In addition, the muscle ratio (GM/TFL) was calculated to determine the ratio of IEMG changes in the GM and TFL muscle activity in each group.

Statistical analysis was performed using IBM SPSS Statistics for Windows, version 27.0 (IBM SPSS Statistics, Japan IBM, Tokyo, Japan). Corresponding t-tests were used to compare muscle torque, IEMG, and MF before and after training, while Student's t-tests were used to compare general characteristics, ratio of change in muscle strength, IEMG, and muscle ratio between groups after checking for equal variances. The significance level was set at 0.05. All values are presented as means ± standard deviation.

RESULTS

The general characteristics of each group are shown in Table 1. There were no significant differences in age, height, and weight between the two groups. The values of muscle torque, IEMG, and MF in each group are shown in Table 2. The comparison of muscle torque before and after training showed no significant differences in the ELTG and GTG. The comparison of IEMG pre- and post-training showed no significant differences in the GM and TFL for ELTG. In the GTG, the IEMG was significantly lower only in the GM compared with that before training. The comparison of MF before and after training showed significant increases in both GM and TFL for ELTG but not GTG. The IEMG changes and muscle ratios before and after training are shown in Table 3. The IEMG changes before and after training did not differ significantly between the groups in both GM and TFL, and the muscle ratio was significantly higher in ELTG than in GTG.

DISCUSSION

This study examined the effects of hip abductor training with ELT on the hip abductor muscles compared with general hip abductor training with a weight band.

The results showed that the IEMG of GM decreased after training in the GTG; however, there was no change in muscle

Table 1. General participant characteristics

	ELTG (n=20)	GTG (n=19)	95% CI
Age (years)	20.2 ± 0.7	19.9 ± 0.9	−0.3 to 0.8
Height (cm)	172.0 ± 4.8	170.6 ± 6.4	−2.3 to 5.1
Weight (kg)	66.2 ± 6.8	62.8 ± 6.7	−1.0 to 7.8

ELTG: elongation training group; GTG: general training group; CI: confidence interval.

Table 2. Comparisons of integral electromyogram and median power frequency before and after training

		ELTG (n=20)			GTG (n=19)		
		Before	After	95%CI	Before	After	95% CI
Muscle torque (kgf)		26.30 ± 4.69	25.79 ± 4.56	−1.31 to 2.33	26.56 ± 4.64	25.61 ± 5.37	−0.63 to 2.55
IEMG (μV • sec)	GM	0.53 ± 0.52	0.52 ± 0.44	−0.08 to 0.09	0.31 ± 0.17	0.27 ± 0.14	0.01 to 0.08*
	TFL	0.73 ± 0.47	0.68 ± 0.36	−0.08 to 0.19	0.56 ± 0.35	0.57 ± 0.30	−0.09 to 0.08
MF (Hz)	GM	70.38 ± 11.42	75.65 ± 15.05	−10.01 to −0.55*	74.50 ± 18.86	77.19 ± 18.16	−7.51 to 2.14
	TFL	70.64 ± 14.03	78.47 ± 17.63	−12.38 to −3.27*	75.31 ± 16.21	78.81 ± 15.74	−7.16 to 0.17

ELTG: elongation training group; GTG: general training group; CI: confidence interval; IEMG: integrated electromyogram; MF: median power frequency; GM: gluteus medius; TFL: tensor fasciae latae.
*Significant difference compared to pre-training.

Table 3. Comparisons of changes in integral electromyogram and muscle ratio between groups before and after training

		ELTG (n=20)	GTG (n=19)	95% CI
Muscle torque (kgf)		0.99 ± 0.15	0.97 ± 0.13	−0.06 to 0.11
IEMG	GM	1.05 ± 0.33	0.90 ± 0.25	−0.04 to 0.34
	TFL	1.00 ± 0.29	1.14 ± 0.48	−0.39 to 0.12
	Muscle ratio	1.10 ± 0.35	0.86 ± 0.25	0.04 to 0.43*

ELTG: elongation training group; GTG: general training group; CI: confidence interval; IEMG: integrated electromyogram; GM: gluteus medius; TFL: tensor fasciae latae; Muscle ratio: the ratio of IEMG changes in the GM and TFL (GM/TFL).
*Significant difference compared to pre-training.

strength and MF before and after training. The shift of the EMG power spectrum to the lower frequency band reportedly indicates muscle fatigue[17]; moreover, the results of the present study suggested that muscle fatigue did not occur in the hip abductor muscles in the GTG. The importance of assessing the balance of muscle activity has been suggested not only for muscle groups in antagonistic relationships but also for muscles in both superficial and deep as well as cooperative relationships[18, 19]. Therefore, in a group of muscles with action in the same direction, the overactivity of one muscle may produce an inhibitory effect that reduces the activity of the other muscle. The decrease in muscle activity of the GM in the present study may have occurred due to the activity of other muscles, such as the lumbar erector spinae, instead of the GM itself. In contrast, in ELTG, while IEMG did not change with training, the MF increased in both the GM and TFL. An increase in the high-frequency component of the EMG power spectrum is associated with an increase in %MVC and occurs with increased activity of Type II fibers[17, 20]. Therefore, hip abductor training with ELT is likely to increase the activity of the hip abductor muscles owing to the activation of Type II fibers.

Regarding the relationship between GM and TFL, GM inactivity and TFL overactivity can cause lower limb diseases such as iliotibial band syndrome; however, reducing TFL activity and efficiently activating the GM remains challenging[12, 18, 21]. Therefore, training methods and movement instructions that consider the relationship between the GM and TFL, in addition to simply increasing the activity of the hip abductor muscles as a whole, have been widely studied[10–12, 18, 22]. In the present study, the muscle ratio of GM and TFL was higher in ELTG than in GTG. This finding suggested that the GM was relatively more active than TFL in ELTG compared with GTG. The EMG power spectrum varies with myofiber type composition[23]. Sickles et al.[24] reported that Type II fibers account for 94% of the myofiber composition of the TFL, while Sirca et al.[25] reported that the GM includes only about 30% Type II fibers. These differences in myofiber type composition may have influenced the differences in EMG power spectra and IEMG changes between the GM and TFL during ELT and general training. In addition, in ELT, the lower extremities are moved distally as much as possible, as if stretching an elastic band; therefore, the lower extremity joints tend to be in an intermediate position. This may have made it easier to achieve GM muscle activity across the entire lateral hip joint rather than the TFL located anterior to the hip joint. However, in the present study, EMG electrodes were placed only in the middle part of the GM, and the GM was not measured separately for each fiber. Therefore, it was not possible to compare the activities between the TFL and the part of the GM located in the anterior part of the hip joint with an action similar to that of TFL. Moreover, it was not possible to examine factors other than the direction of motion in this study. This is a subject for future study. However, the results of this study suggested that ELT is more useful for increasing GM activity relative to the TFL, compared with general weighted hip abductor training. These results may have important implications for training the hip abductor muscles as a way to train the GM while suppressing TFL activity.

One of the limitations of this study is the inclusion of young healthy males only. The results may differ according to age groups with different myofiber type compositions or in participants with muscle imbalances such as excessive TFL tension or GM atrophy. Thus, further studies are needed to investigate these effects in a wider range of participants. In addition, this study only examined the results immediately after training; further studies are required to examine muscle activity during training and the long-term effects of training. Furthermore, this study focused only on the hip abductor muscles but did not measure the synergist and antagonist muscles such as the lumbar erector spinae, hip flexors, and hip adductor muscles, which is another topic for future investigation.

In conclusion, this study examined the effects of hip abductor training with ELT on the hip abductor muscles compared with general hip abductor training. The muscle ratios of the GM and TFL were greater for hip abductor training with ELT than those for general hip abductor training with a weight band. Therefore, training of the hip abductor muscles by ELT is more useful than general training to activate the GM while suppressing the TFL activity.

Funding and Conflict of interest

The authors certify that there is no funding and conflict of interest with any financial organization regarding the material discussed in the manuscript.

REFERENCES

1) Earl JE: Gluteus medius activity during 3 variations of isometric single-leg stance. J Sport Rehabil, 2005, 14: 1–11. [CrossRef]
2) Ganderton C, Pizzari T, Cook J, et al.: Gluteus minimus and gluteus medius muscle activity during common rehabilitation exercises in healthy postmenopausal women. J Orthop Sports Phys Ther, 2017, 47: 914–922. [Medline] [CrossRef]
3) Retchford TH, Crossley KM, Grimaldi A, et al.: Can local muscles augment stability in the hip? A narrative literature review. J Musculoskelet Neuronal Interact, 2013, 13: 1–12. [Medline]
4) Rasch A, Byström AH, Dalen N, et al.: Reduced muscle radiological density, cross-sectional area, and strength of major hip and knee muscles in 22 patients with hip osteoarthritis. Acta Orthop, 2007, 78: 505–510. [Medline] [CrossRef]
5) Fredericson M, Cookingham CL, Chaudhari AM, et al.: Hip abductor weakness in distance runners with iliotibial band syndrome. Clin J Sport Med, 2000, 10: 169–175. [Medline] [CrossRef]
6) Mucha MD, Caldwell W, Schlueter EL, et al.: Hip abductor strength and lower extremity running related injury in distance runners: a systematic review. J Sci Med Sport, 2017, 20: 349–355. [Medline] [CrossRef]
7) Arab AM, Nourbakhsh MR: The relationship between hip abductor muscle strength and iliotibial band tightness in individuals with low back pain. Chiropr Osteopat, 2010, 18: 1. [Medline] [CrossRef]
8) Bolgla LA, Malone TR, Umberger BR, et al.: Comparison of hip and knee strength and neuromuscular activity in subjects with and without patellofemoral pain syndrome. Int J Sports Phys Ther, 2011, 6: 285–296. [Medline]
9) Beckman SM, Buchanan TS: Ankle inversion injury and hypermobility: effect on hip and ankle muscle electromyography onset latency. Arch Phys Med Rehabil, 1995, 76: 1138–1143. [Medline] [CrossRef]
10) McBeth JM, Earl-Boehm JE, Cobb SC, et al.: Hip muscle activity during 3 side-lying hip-strengthening exercises in distance runners. J Athl Train, 2012, 47: 15–23. [Medline] [CrossRef]
11) Distefano LJ, Blackburn JT, Marshall SW, et al.: Gluteal muscle activation during common therapeutic exercises. J Orthop Sports Phys Ther, 2009, 39: 532–540. [Medline] [CrossRef]
12) Selkowitz DM, Beneck GJ, Powers CM: Which exercises target the gluteal muscles while minimizing activation of the tensor fascia lata? Electromyographic assessment using fine-wire electrodes. J Orthop Sports Phys Ther, 2013, 43: 54–64. [Medline] [CrossRef]
13) Miyachi R, Miyazaki J, Mori K, et al.: Comparison of muscle activity based on ankle position during hip abduction. J Asian Orthop Manip Phys Ther, 2020, 1: 10–17.
14) Nishimura T, Miyachi R: Does elongation training effectively improve motor function?—A single-case design verification study. J Phys Ther Sci, 2020, 32: 418–421. [Medline] [CrossRef]
15) Kito N, Kaneguchi A, Ozawa J: Foundation and practice of muscle strength exercise. Rehabil Igaku, 2017, 54: 746–751.
16) Criswell E, ed.: Cram's introduction to surface electromyography, 2nd ed. London: Jones and Bartlett Publishers, 2008, pp 356–360.
17) Komi PV, Tesch P: EMG frequency spectrum, muscle structure, and fatigue during dynamic contractions in man. Eur J Appl Physiol Occup Physiol, 1979, 42: 41–50. [Medline] [CrossRef]
18) Bishop BN, Greenstein J, Etnoyer-Slaski JL, et al.: Electromyographic analysis of gluteus maximus, gluteus medius, and tensor fascia latae during therapeutic exercises with and without elastic resistance. Int J Sports Phys Ther, 2018, 13: 668–675. [Medline] [CrossRef]
19) Key J, Clift A, Condie F, et al.: A model of movement dysfunction provides a classification system guiding diagnosis and therapeutic care in spinal pain and related musculoskeletal syndromes: a paradigm shift-Part 1. J Bodyw Mov Ther, 2008, 12: 7–21. [Medline] [CrossRef]
20) Hagberg M, Ericson BE: Myoelectric power spectrum dependence on muscular contraction level of elbow flexors. Eur J Appl Physiol Occup Physiol, 1982, 48: 147–156. [Medline] [CrossRef]
21) Fredericson M, Wolf C: Iliotibial band syndrome in runners: innovations in treatment. Sports Med, 2005, 35: 451–459. [Medline] [CrossRef]
22) Lee JH, Cynn HS, Choi SA, et al.: Effects of different hip rotations on gluteus medius and tensor fasciae latae muscle activity during isometric side-lying hip abduction. J Sport Rehabil, 2013, 22: 301–307. [Medline] [CrossRef]
23) Bilodeau M, Arsenault AB, Gravel D, et al.: Influence of gender on the EMG power spectrum during an increasing force level. J Electromyogr Kinesiol, 1992, 2: 121–129. [Medline] [CrossRef]
24) Sickles DW, Oblak TG: Metabolic variation among alpha-motoneurons innervating different muscle-fiber types. I. Oxidative enzyme activity. J Neurophysiol, 1984, 51: 529–537. [Medline] [CrossRef]
25) Sĭrca A, Susec-Michieli M: Selective type II fibre muscular atrophy in patients with osteoarthritis of the hip. J Neurol Sci, 1980, 44: 149–159. [Medline] [CrossRef]