

# Effect of KAATSU training on thigh muscle size and safety for a patient with knee meniscectomy over 3 years

Tomohiro Yasuda<sup>1,2)</sup>, Seiya Oosumi<sup>3)</sup>, Shinpei Sugimoto<sup>3)</sup>, Toshihiro Morita<sup>3)</sup>, Yoshiaki Sato<sup>4)</sup>, Masanori Ishii<sup>3,5)</sup>, Toshiaki Nakajima<sup>2,6)</sup>.

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Correspondence to:  
Tomohiro Yasuda, PhD.  
School of Nursing, Seirei  
Christopher University  
3453, Mikatahara, Kita-Ku,  
Hamamatsu, Shizuoka,  
433-8558, Japan  
E-Mail: tomohiro-y@seirei.ac.jp  
Phone: +81-53-439-1417  
Fax: +81-53-439-1406

See end of article for  
authors' affiliations

**[Objective]** It is well known that knee meniscectomy is one of the major knee surgeries, which induces thigh muscle atrophy. However, it is unclear whether thigh muscle size after knee meniscectomy can be improved with KAATSU training. We examined effect of KAATSU training on thigh muscle size and safety for a patient with knee meniscectomy.

**[Methods]** The patient was a 57-year-old woman (standing height 159 cm and body weight 52 kg). The KAATSU training composed of 7 types of resistance exercise and one type of cycling exercise was provided for a total of 125 sessions over approximately 3 years. Transverse scans were carried out for mid-thigh length. Thigh muscle cross-sectional area (CSA) in affected-leg and unaffected-leg was measured by the CT scan before, 63 weeks, and 152 weeks after the training.

**[Results]** Thigh muscle CSA was highly increased for affected-leg, and the attained level was exactly similar for both legs after the 152 weeks training period.

**[Conclusion]** The long-term KAATSU exercises were a highly safe and effective training method for a patient with knee meniscectomy.

**Key words:** knee meniscectomy, muscle hypertrophy, thigh muscle, long duration, rehabilitation.

## Introduction

It is well known that knee meniscectomy is one of the major knee surgeries, which induces thigh muscle atrophy (Akima and Furukawa, 2005; Ericsson et al., 2006). In general, traditional high-intensity exercise training ( $\geq 70\%$  1-repetition maximum: 1RM) improves skeletal muscle morphology and function (ACSM, 2009), but it appears that this method is not practical and may even be dangerous in patients with knee meniscectomy. On the other hand, KAATSU training ( $\leq 30\%$  1RM) can produce muscle hypertrophy and does not decrease vascular function (Ozaki et al., 2013; Yasuda et al., 2015; Yasuda et al., 2016). Additionally, recent studies (Nakajima et al., 2015; Hiraizumi et al., 2016) reported that KAATSU training is quite useful as a rehabilitation method in disorder of bone (femoral head avascular necrosis, femoral medial condyle osteonecrosis). However, it is unclear whether thigh muscle size after knee meniscectomy can be improved with KAATSU training.

Thus, the purpose of this study was to examine effect of KAATSU training on thigh muscle size and safety for a

patient with knee meniscectomy.

## 1. Case review

Patient: A 57-year-old woman (standing height 159 cm, body weight 52 kg), a physical education teacher

Diagnosis: knee meniscectomy

Chief complaint: Left knee joint pain on walking.

Family history of illness: No notable findings.

History of present illness & course of symptoms: On 15 October, 2014, she received meniscectomy implementation of the left knee under arthroscopy, and visited Okamoto-Ishii Hospital for receiving rehabilitation. At the first visit, the patient was suffering from strong leg swelling, heat sensation, and severe pain for left knee and was unable to walk without a cane. The KAATSU training started from October 30. At the start of rehabilitation, after performing pressurization / depressurization, exercises of isometric contraction without joint movement were performed. After that, she received icing. The pain gradually decreased, and she could raise the stairs with crutches. After 1 month of KAATSU training, her pain was remark-

1) School of Nursing, Seirei Christopher University, Shizuoka, Japan

2) Department of Cardiovascular Medicine, School of Medicine, Dokkyo Medical University, Tochigi, Japan

3) Okamoto-Ishii Hospital, Shizuoka, Japan

4) Center for KAATSU Research at Harvard Medical School, Massachusetts, USA.

5) Department of Geriatric Medicine, Graduate School of Medicine, The University of Tokyo, Japan.

6) Heart Center, School of Medicine, Dokkyo Medical University Hospital, Tochigi, Japan

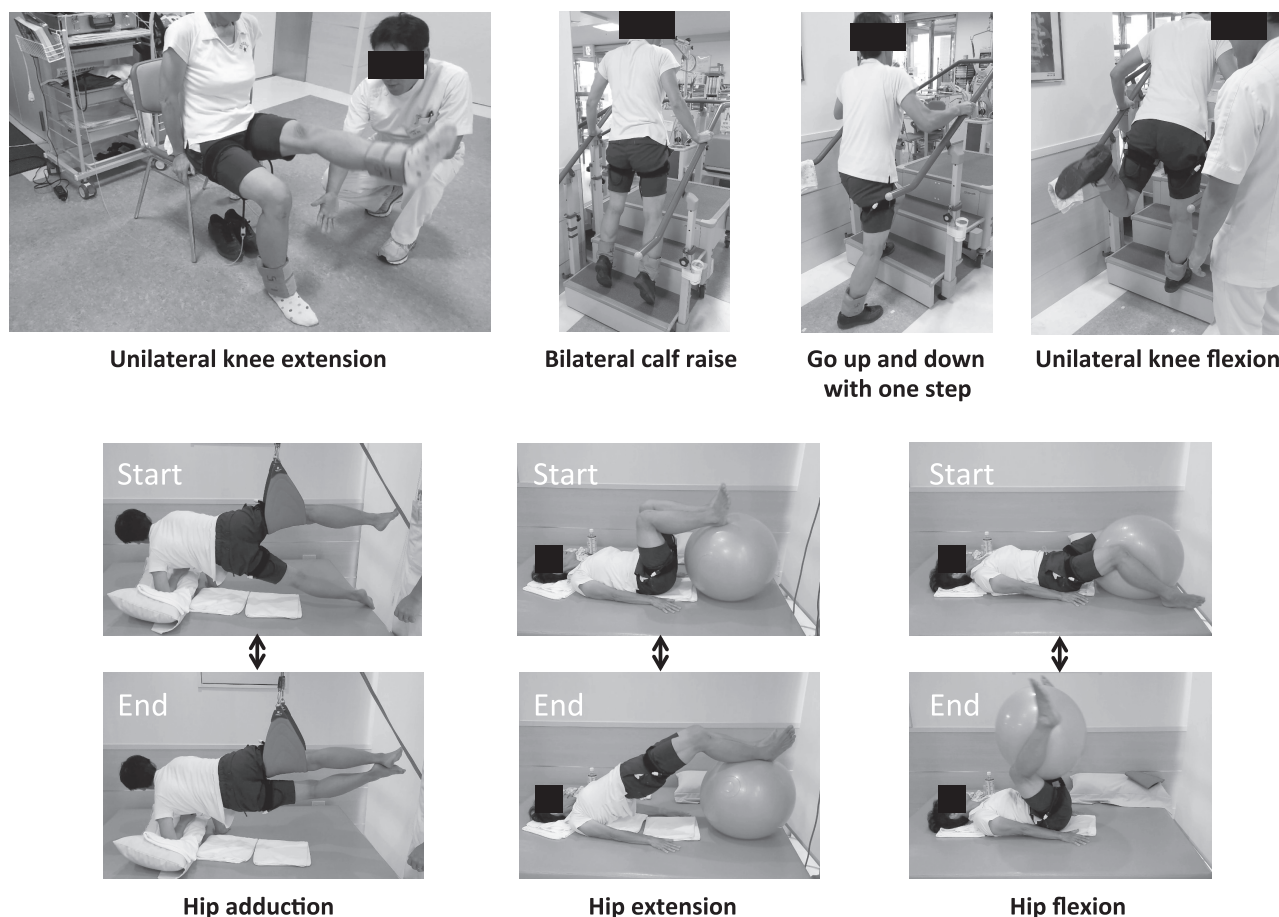


Figure 1. Pictures show 7 types of KAATSU resistance training.

ably mitigated and she was able to walk without cane. On January, 2015, the pain was abolished. After 9 months, she was able to go upstairs and downstairs, and began to run a little without pain. She noticed the increase of muscle power and mass. After that, she also began to climb the stairs without problems, and could run through the hallway, and jump rope in physical education class. At present, she is doing mountain climbing at her elementary school excursions. On September 2017, she has received KAATSU training for approximately three years. Any side effects have not been occurred during the long-term training.

The principles of the World Medical Association Declaration of Helsinki and the American College of Sports Medicine Guidelines for Use of Human Subjects were adopted in this study. The study was approved by the Ethics Committee, and informed assent consent was obtained from the patient.

## 2. KAATSU training protocol

During the KAATSU training sessions, a patient wore a specially designed pneumatic cuff (50 mm width, KAATSU Master, KAATSU Japan Co., Ltd., Tokyo, Japan) around the most proximal portion of both thighs. KAATSU training was provided for a total of 125 sessions over approximately 3 years (from October 2014 to September 2017, 152 weeks). Basically, the cuffs were set at 40 SKU

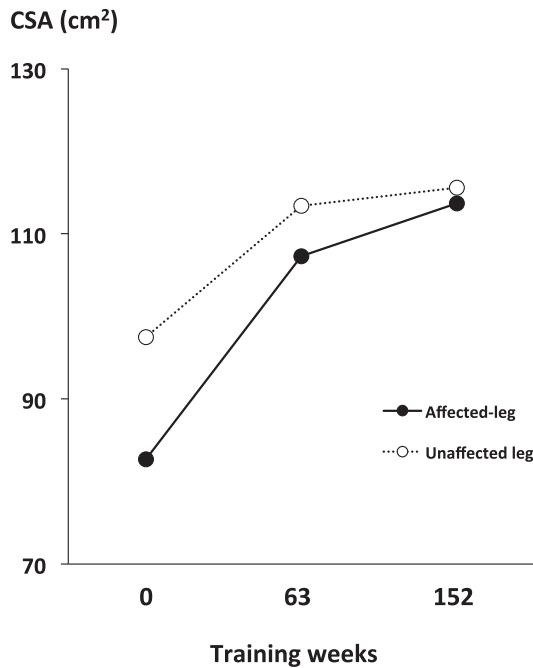
Figure 2. KAATSU training protocols for each session.

Exercise	Menu	Intensity
Unilateral knee extension	6 sets (30, 30, 20, 20, 10, 10 reps)	Lower leg weight + 1.5 kg weight
Bilateral calf raise	6 sets (30, 30, 20, 20, 10, 10 reps)	Body weight + 3.0 kg weight
Go up and down with one step	6 sets (30, 30, 20, 20, 10, 10 reps)	Body weight + 1.5 kg weight
Unilateral knee flexion	6 sets (30, 30, 20, 20, 10, 10 reps)	Lower leg weight + 1.5 kg weight
Hip adduction	6 set (30, 30, 20, 20, 10, 10 reps)	Lower leg weight
Hip extension	3 sets (30, 20, 10)	Lower body weight
Hip flexion	3 sets (30, 20, 10)	Lower body weight
Bicycle ergometer	30 min	65-70 watt

and air pressure was inflated to 200 SKU. The training protocol (7 types of resistance exercise and one type of cycling exercise) was shown as Figure 1 and 2. Eight exercises over 60 min were performed each session.

## 3. Computed tomographic (CT) finding

Subjects rested quietly in the body coil in a supine position with their legs extended and relaxed. Transverse scans were carried out for mid-thigh length (from the top edge



**Figure 3.** Thigh muscle cross-sectional area (CSA) in affected-leg and unaffected-leg before, 63 weeks, and 152 weeks after training.

of the great trochanter to the lateral condyle of femur). From the cross-sectional image, outlines of the thigh muscles were traced, and digitized by using a personal computer (MacBook, Apple, Tokyo, Japan) for analysis using image analysis software (Image J 1.5, NIH, USA), and muscle CSA was calculated. The CT scan was measured at October 9, 2014, December 24, 2015, and September 9, 2017. Thigh muscle CSA was highly increased for affected-leg, and the attained level was exactly similar for both legs at September 9, 2017 (Figure 3).

## Discussion

The improvement of intrinsic morphology for the thigh muscles is important in exercise training for patients with knee injury and knee surgery. To the best of our knowledge, this is the first study to investigate the effect of KAATSU training on muscle strength and function for a patient with knee meniscectomy. The primary finding of this study was that KAATSU training remarkably increased the thigh muscle CSA for affected-leg, which was comparable with the unaffected-leg after the long-term period for 152 weeks.

Our findings show that KAATSU training after 63 weeks produces a hypertrophic potential of 0.33% per session for unaffected-leg, which is similar to that observed following KAATSU training after 12 weeks using weight machines (0.33% per session, Yasuda et al. 2014). This suggests that this training protocol is enough method for improving thigh muscle size for unaffected-leg over a long period. Additionally, the increase in thigh muscle CSA is approximately 2-fold higher in for affected-leg (0.61% per

session) compared to unaffected-leg after the 63 weeks training period. Taken together, KAATSU training using body weight can induce large improvement in thigh muscle size for a patient with knee meniscectomy over the long period.

In the present study, heart rate and ratings of perceived exertion during 7 types of KAATSU resistance exercises (90-129 BPM and 11-16, respectively) and KAATSU cycling exercise (~127 BPM and ~11, respectively) were not high level (data not shown). These results are similar to that reported in previous KAATSU training studies for healthy subjects (Yasuda et al., 2014; Kim et al., 2016; Yasuda et al., 2016). Thus, it appears that these KAATSU exercises were a highly safe and effective training method for a patient with knee meniscectomy.

In conclusion, KAATSU training is potentially highly useful as a new method of rehabilitation for a patient with knee meniscectomy.

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