

# Effect of 24 weeks of KAATSU resistance training on femoral muscle size and safety in a 84-year-old woman.

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## Abstract

[Objective] It is well known that KAATSU resistance training can produce muscle hypertrophy without deteriorating cardiovascular system in older adults. However, it is unclear whether KAATSU resistance training exceeding 12 weeks were a highly safe and effective training method for improvement of skeletal muscle mass in older adults. We examined effect of 24 weeks of KAATSU resistance training on femoral muscle size and its safety for older adult.

[Methods] The subject was an 84-year-old woman (standing height 153 cm and body weight 46 kg). The KAATSU resistance training was provided for a total of 48 sessions over 24 weeks. Training intensity and volume were set at 20% or 30% of one-repetition maximum (1-RM) and 75 repetitions for knee extension and leg press exercises, respectively. Mid-thigh muscle cross-sectional area (CSA) was measured by MRI scan before, 12 weeks, and 24 weeks after the training. The maximal strength, chair-stand test, hemodynamic parameters, arterial stiffness, coagulation system and muscle damage were also measured.

[Results] Quadriceps muscle CSA, 1-RM strength and chair-stand test increased throughout 24-week training period. On the other hand, there were no changes in body weight, hemodynamic parameters (except for systolic blood pressure), arterial compliance coagulation system and muscle damage throughout the training period.

[Conclusion] The 24 weeks of KAATSU resistance training may be a highly safe and effective training method for improvement of skeletal muscle mass in older adults.

**Key word:** blood flow restriction, muscle hypertrophy, muscle strength, sarcopenia, thigh muscle

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## 1. Introduction

Skeletal muscle atrophy with aging is associated with serious problems (i.e. falls, fractures, disability, and heart disease)<sup>9,21,25)</sup> and it is also associated with increased healthcare costs<sup>10)</sup>. Loss of skeletal muscle mass can therefore drastically impair quality of life and can also reduce life expectancy and healthy life expectancy. Among the countries belonging to the Organisation for Economic Co-operation and Development (OECD), Japan is a leading country with a high estimated average healthy life expectancy (71.4 and 75.8 year for men and women in 2001, respectively)<sup>13)</sup>, but a large gap period obtained by subtracting the healthy life expectancy from life expectancy was 8.0-8.9 and 9.7-10.8 year for men and women from 1990 through 2013<sup>20)</sup>. In order to shorten this large gap period as much as possible, there is a pressing need to promote and achieve healthy life expectancy by long-period intervention.

Resistance training is the most effective intervention as improvement of skeletal muscle mass. In general, traditional high-intensity resistance training ( $\geq 70\%$  1-repetition maximum: 1RM) improves skeletal muscle morphology and function<sup>3)</sup>, but it appears that this method is not practical and even decrease cardiovascular system in older adults<sup>14)</sup>. On the other hand, KAATSU resistance training ( $\sim 30\%$  1RM) can produce muscle hypertrophy and does not decrease cardiovascular system in older adults as well as young adults<sup>1,17,23,24)</sup>. However, since most KAATSU resistance training studies only limited to short-period (within 12 weeks)<sup>5)</sup>, it is unclear whether the long-period (exceeding 12 weeks) of KAATSU resistance training was a highly safe and effective training method for improvement of skeletal muscle mass in older adults.

Skeletal muscle atrophy with aging is muscle specific and that greater quadriceps muscle loss was found in older adults<sup>2,15)</sup>. Thus, the purpose of this case study was to ex-

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amine effect of a 24-week KAATSU training on femoral muscle size and safety for older adult.

## 2. Subject

A 84-year-old woman (standing height, 153 cm) participated in this study. She had no participated in resistance-type training prior to the study, and was free of overt chronic disease as assessed by medical history, physical examination, and complete chemistry and hematologic evaluation. 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 consent were obtained from the subject.

## 3. Methods

The subject performed bilateral knee extension and leg press exercise training 2 days/week for 24 weeks. This training was performed under the close supervision of those with technical knowledge in BFR training. Three or four days before training, the subject performed one-repetition maximum (1-RM) test, which was estimated by the 10-RM method<sup>4)</sup>. Training intensity and volume were set at 20% or 30% of 1-RM and 75 repetitions for knee extension and leg press exercises, respectively. This protocol is typical of submaximal BFR studies<sup>23,24)</sup>. During knee extension and leg press exercises, the subject was seated comfortably on isotonic knee extension (VR1, Cybex International, Inc.) and leg press machines (Seated Leg Press, Life Fitness), with the body supported in a vertical position. The training loads of each exercise was adjusted based on estimated 1-RM testing performed every 3 weeks. During the training sessions, the subject wore a specially designed elastic pressure cuff (50 mm width, KAATSU Master, Sato Sports Plaza, Tokyo, Japan) around the most proximal portion of the both legs. On the first day of training, the cuff was set at 120 S.K.U. The pressure was increased by 10-20 S.K.U. at each subsequent training session until a pressure of approximately 200 S.K.U. was reached. Immediately after the exercise session, the pressure cuff was quickly removed.

The subject testing took place before the start of the study (pre), 3-5 days after the 12-week and 24-week of training. Muscle cross-sectional area (CSA) was obtained using a magnetic resonance imaging (MRI) scanner (1.5-T MRI, Hitachi, Tokyo, Japan). A T-1 weighted spin-echo axial plane sequence was performed with a 540-msec repetition time and a 20-msec echo time. Subjects rested quietly in the magnet bore in a supine position with their legs extended. Continuous transverse images (10-mm slice thickness) were transferred to a personal computer for analysis using specially designed image analysis software (sliceOmatic, Tomovision Inc., QC, Canada). CSA data for the quadriceps, adductors and hamstrings at 50% of thigh length and for the Gluteus maximus at the top edge of the great trochanter were digitized. Bilateral knee exten-

sion and leg press maximum dynamic strength (1-RM) were assessed using an isotonic knee extension and leg press machines. During estimated 1-RM testing as well as training sessions, the parallel leg stance width was set at 100% of the shoulder-width for leg press exercises. A chair-stand test required participants to stand up from a seated position, as many times as possible, within 30 seconds<sup>18)</sup>. Hemodynamic parameter, cardio-ankle vascular index (CAVI) and ankle-brachial pressure index (ABI) were measured noninvasively using a VS-1500 system (Fukuda Denshi Co., Ltd, Tokyo, Japan). CAVI and ABI were obtained by substituting the stiffness parameter into an equation for determining vascular elasticity<sup>19)</sup>. Venous blood samples were obtained from the antecubital vein and measured for fibrin/fibrinogen degradation products (FDP), D-dimer and creatine kinase (CK). The plasma concentrations of these samples were measured at a commercial laboratory (SRL Inc., Tokyo, Japan) by following latex immunoassay (LIA) for fibrin/fibrinogen degradation products (FDP) and D-dimer and spectrophotometry for NADPH formed by a hexokinase and D-glucose-6-phosphate-dehydrogenase-coupled enzymic system for CK.

## 4. Results

After 24-week training period, quadriceps and adductors muscle CSA (14% and 9%), knee extension and leg press 1-RM (43% and 60%) and chair-stand performance (29%) showed marked increase. In particular, quadriceps muscle CSA, both 1-RM strength and chair-stand test increased throughout 24-week training period. On the other hand, there were no changes in body weight, hemodynamic parameters (except for systolic blood pressure), arterial stiffness, coagulation system and muscle damage throughout the training period (Table 1).

## 5. Discussion

The main findings of the present study were: (1) 24-week KAATSU resistance training can lead to increase in muscle CSA as well as maximal strength for older adult, (2) hemodynamic parameters, arterial stiffness, coagulation factors, and CK, a marker of muscle damage were not changed throughout the training period.

Our results showed that KAATSU resistance training produced a hypertrophic potential of 0.31% and 0.28% per session in quadriceps muscle CSA (for 12- and 24-weeks, respectively), which is similar to that observed following high-intensity resistance training at 80% 1-RM (0.26%-0.45%) in elderly adults<sup>7,8)</sup>. Additionally, the observed gains in knee extension (1.39% and 0.88% per session for 12- and 24-weeks, respectively) and leg press 1-RM strength (1.60% and 1.25% per session for 12- and 24-weeks, respectively) were comparable with the previous KAATSU study at 20% 1-RM (knee extension: 1.06%, leg press: 1.07% per session, respectively)<sup>11)</sup>. Therefore, our data suggested that KAATSU resistance training (at 20-30% 1-RM) can provide an effective hypertrophic stimulus on thigh muscles for long-period in older adults.

**Table 1.** Body weight, muscle size, muscle strength, hemodynamic parameter, arterial compliance, coagulation system and muscle damage before (baseline), 12 weeks, and 24 weeks after KAATSU resistance training.

	Baseline	12 weeks	24 weeks
Body weight (kg)	45.5	45.5	44.9
Muscle cross-sectional area (cm <sup>2</sup> )			
Gluteus maximus	30.7	31.9	31.5
Quadriceps femoris	35.1	37.7	39.9
Hamstrings	22.2	21.5	22.0
Adductors	26.2	26.3	28.7
Muscle strength (kg)			
Knee extension 1-RM	33	44	47
Leg press 1-RM	138	191	221
Functional ability test			
Chair stand (reps/30-sec)	14	16	18
Hemodynamic parameter			
Heart rate (bpm)	63	61	67
Systolic BP (mmHg)	152	134	142
Diastolic BP (mmHg)	86	84	86
Arterial compliance			
CAVI (m/sec)	10.6	11.2	10.3
ABI (unit)	1.01	1.19	1.18
Coagulation system/muscle damage			
D-dimer (10 <sup>-5</sup> g/L)	0.28	0.53	0.31
FDP (10 <sup>-5</sup> g/L)	3	2	2
CK (IU/l)	64	54	55

ABI, ankle-brachial pressure index; BP, blood pressure; CAVI, cardio-ankle vascular index; CK, creatine kinase; FDP, fibrin/fibrinogen degradation products.

In this study, maximum heart rate and ratings of perceived exertion during each KAATSU resistance exercise (100-155 BPM and 15-19, respectively; data not shown) were not low level compared with previous KAATSU training studies for older adults<sup>12,22,24</sup>. However, hemodynamic parameters (heart rate and blood pressure), arterial stiffness (CAVI), coagulation factors (FDP and d-dimer), and muscle damage (CK) were not changed throughout the training period. Thus, it appears that these KAATSU resistance exercises were a highly safe and effective training method even if the older adults feel with sufficiently hard training protocol. However, it should be noted that the possibility of side effects cannot be denied when subjects perform such training until near exhaustion or particularly to complete exhaustion<sup>6,16,26</sup>. Additional research is needed to understand the relationship between the long-period of KAATSU resistance training and muscle hypertrophy/safety for many older adults.

In conclusion, 24 weeks of KAATSU resistance training were a highly safe and effective training method for improvement of skeletal muscle mass in older adult. Thus, the long-period intervention by KAATSU resistance training may be considered as a useful way to prolong the healthy life expectancy in older adults.

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## References

1. **Abe T**, Yasuda T, Midorikawa T, Sato Y, Kearns CF, Inoue K, Koizumi K, Ishii N (2005) Skeletal muscle size and circulating IGF-1 are increased after two weeks of twice daily "KAATSU" resistance training. *Int J Kaatsu Training Res* 1: 6-12.
2. **Abe T**, Sakamaki M, Yasuda T, Bemben MG, Kondo M, Kawakami Y, Fukunaga T (2011) Age related, site-specific muscle loss in 1507 Japanese men and women aged 20 to 95 years. *J Sports Sci Med* 10: 145-150.
3. **American College of Sports Medicine** (2009) American College of Sports Medicine position stand. Progression models in resistance training for healthy adults. *Med Sci Sports Exerc* 41: 687-708.
4. **Baechle TR**, Earle RW (2008) Resistance training. *Essentials of Strength Training and Conditioning*. 3rd edn. Champaign, IL: Human Kinetics.
5. **Centner C**, Wiegel P, Gollhofer A, König D (2019) Effects of Blood Flow Restriction Training on Muscular Strength and Hypertrophy in Older Individuals: A Systematic Review and Meta-Analysis. *Sports Med*. 49: 95-108.
6. **Clark BC**, Manini TM, Hoffman RL, Williams PS, Guiler MK, Knutson MJ, McGlynn ML, Kushnick MR (2011) Relative safety of 4 weeks of blood flow-restricted resistance exercise in young, healthy adults. *Scand J Med Sci Sports*. 21: 653-662.
7. **Frontera WR**, Meredith CN, O'Reilly KP, Knuttgen HG, Evans WJ (1988) Strength conditioning in older men: skeletal muscle hypertrophy and improved function. *J Appl Physiol*. 64: 1038-1044.
8. **Fiatarone MA**, Marks EC, Ryan ND, Meredith CN, Lipsitz LA, Evans WJ (1990) High-intensity strength training in nonagenarians. Effects on skeletal muscle. *JAMA*. 263: 3029-3034.
9. **Haykowsky MJ**, Brubaker PH, Morgan TM, Kritchevsky S, Eggebeen J, Kitzman DW (2013) Impaired aerobic capacity and physical functional performance in older heart failure patients with preserved

- ejection fraction: role of lean body mass. *J Gerontol A Biol Sci Med Sci.* 68: 968-975.
10. **Janssen I**, Shepard DS, Katzmarzyk PT, Roubenoff R (2004) The healthcare costs of sarcopenia in the United States. *J Am Geriatr Soc.* 52: 80-85.
  11. **Karabulut M**, Abe T, Sato Y, Bemben MG (2010) The effects of low-intensity resistance training with vascular restriction on leg muscle strength in older men. *Eur J Appl Physiol.* 108: 147-155.
  12. **Kim D**, Singh H, Loenneke JP, Thiebaud RS, Fahs CA, Rossow LM, Young K, Seo DI, Bemben DA, Bemben MG (2016) Comparative Effects of Vigorous-Intensity and Low-Intensity Blood Flow Restricted Cycle Training and Detraining on Muscle Mass, Strength, and Aerobic Capacity. *J Strength Cond Res.* 30: 1453-1461.
  13. **Mathers CD**, Murray CJ, Salomon JA, Sadana R, Tandon A, Lopez AD, Ustün B, Chatterji S (2003) Healthy life expectancy: comparison of OECD countries in 2001. *Aust N Z J Public Health.* 27: 5-11.
  14. **Miyachi M**, Kawano H, Sugawara J, Takahashi K, Hayashi K, Yamazaki K, Tabata I, Tanaka H (2004) Unfavorable effects of resistance training on central arterial compliance: a randomized intervention study. *Circulation.* 110: 2858-2863.
  15. **Miyatani M**, Kanehisa H, Azuma K, Kuno S, Fukunaga T (2003) Site-related differences in muscle loss with aging: a cross sectional survey on the muscle thickness in Japanese men and Age-related muscle loss in Japanese adults 150 women aged 20 to 79 years. *Int J Sport Health Sci.* 1: 34-40.
  16. **Nakajima T**, Kurano M, Iida H, Takano H, Oonuma H, Morita T, Meguro K, Sato Y, Nagata T, KAATSU Training Group (2006) Use and safety of KAATSU training: Results of a national survey. *Int J KAATSU Training Res* 2:5-13.
  17. **Ozaki H**, Yasuda T, Ogasawara R, Sakamaki-Sunaga M, Naito H, Abe T (2013) Effects of high-intensity and blood flow-restricted low-intensity resistance training on carotid arterial compliance: role of blood pressure during training sessions. *Eur J Appl Physiol.* 113: 167-174.
  18. **Rikli RE**, Jones CJ (1990) Development and validation of a functional fitness test for community-residing older adults. *J Aging Phys Act.* 7: 129-161.
  19. **Shirai K**, Otsuka K, Takata M (2006) A novel blood pressure-independent arterial wall stiffness parameter; cardio-ankle vascular index (CAVI). *J Atheroscler Thromb.* 13: 101-107.
  20. **Tokudome S**, Hashimoto S, Igata A (2016) Life expectancy and healthy life expectancy of Japan: the fastest graying society in the world. *BMC Res Notes.* 9: 482.
  21. **Visser M**, Kritchevsky SB, Goodpaster BH, Newman AB, Nevitt M, Stamm E, Harris TB (2002) Leg muscle mass and composition in relation to lower extremity performance in men and women aged 70 to 79: the Health, Aging and Body Composition Study. *J Am Geriatr Soc.* 50: 897-904.
  22. **Yasuda T**, Fukumura K, Fukuda T, Uchida Y, Iida H, Meguro M, Sato Y, Yamasoba T, Nakajima T (2014) Muscle size and arterial stiffness after blood flow-restricted low-intensity resistance training in older adults. *Scand J Med Sci Sports.* 24: 799-806.
  23. **Yasuda T**, Fukumura K, Uchida Y, Koshi H, Iida H, Masamune K, Yamasoba T, Sato Y, Nakajima T (2015) Effects of Low-Load, Elastic Band Resistance Training Combined With Blood Flow Restriction on Muscle Size and Arterial Stiffness in Older Adults. *J Gerontol A Biol Sci Med Sci.* 70: 950-958.
  24. **Yasuda T**, Fukumura K, Tomaru T, Nakajima T (2016) Thigh muscle size and vascular function after blood flow-restricted elastic band training in older women. *Oncotarget.* 7: 33595-225607.
  25. **Yasuda T**, Nakajima T, Sawaguchi T, Nozawa N, Arakawa T, Takahashi R, Mizushima Y, Katayanagi S, Matsumoto K, Toyoda S, Inoue T (2017) Short Physical Performance Battery for cardiovascular disease inpatients: implications for critical factors and sarcopenia. *Sci Rep.* 7: 17425.
  26. **Yasuda T**, Meguro M, Sato Y, Nakajima T (2017) Use and safety of KAATSU training: Results of a national survey in 2016. *Int J Kaatsu Training Res* 13: 1-9.

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