

Kaatsu Training: Application to Metabolic Syndrome

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Int. J. KAATSU Training Res. 2011; 7: 7-12

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Kaatsu training (*hereafter* Kaatsu) was applied to patients with metabolic syndrome. **PURPOSE:** To evaluate the effect of Kaatsu on patients with hypertension, diabetes mellitus, dyslipidemia, and obesity with metabolic syndrome. **METHOD:** A 3-exercise set of Kaatsu was performed for 6-12 minutes, once or twice a week with a Borg scale at level 13. The usefulness of Kaatsu was evaluated 3 to 4 months later. In this study, patients were instructed not to change their lifestyles (e.g. food, medicine and exercise). **RESULTS:** The effectiveness of Kaatsu was shown in 31 out of 51 patients (61%) to which Kaatsu was applied. In 12 out of 18 patients (67%) with hypertension, systolic blood pressure dropped from an average of 166 mmHg to 146 mmHg and diastolic blood pressure also dropped from an average of 96 mmHg to 86 mmHg. In 6 out of 10 patients (60%) with diabetes mellitus, HbA1c dropped from an average of 6.8% to 6.12%. In 8 out of 14 patients (57%) with dyslipidemia, LDL-c decreased from an average of 158 mg/dl to 136 mg/dl. In 5 out of 9 patients (56%) with obesity, there was a reduction in weight from an average of 67 kg to 59 kg. **DISCUSSION AND CONCLUSION:** Kaatsu training improves physical conditions including hypertension, diabetes mellitus, dyslipidemia and obesity with metabolic syndrome.

Key words: Kaatsu training, growth hormone, metabolic syndrome, somatopause

INTRODUCTION

Metabolic syndrome is defined as a condition of visceral fat accumulation with a combination of two or more of hyperglycemia, hypertension or dyslipidemia. These closely resemble the symptoms of somatopause which is the condition of decreasing growth hormone (*hereafter* GH) secretion with aging. On the other hand, Kaatsu has brought about a variety of good effects in muscle strength (Takarada et al., 2000; Abe et al., 2005), lipolysis (Satoh, 2011) and health promotion. Kaatsu has also been applied in the field of medical care (Nakajima et al., 2007). In my clinic, exercise therapy, especially walking, has become valued for the treatment and prevention of metabolic syndrome (Satoh, 1990). Nevertheless, in cases of patients with a walking disturbance or patients who cannot spare one hour or more for walking, Kaatsu has been proactively introduced and good results were obtained (Satoh, 2006). This method can be performed in a short period of time, without placing a burden on the knees and the lower back. Furthermore, it is believed that there is a good effect even with metabolic syndrome because of the secretion of GH. Therefore, the effectiveness of Kaatsu on metabolic syndrome was evaluated in this study.

METHODS

Subjects

The subjects of this study were 51 patients with metabolic syndrome (14 males and 37 females) out of 96 patients treated with Kaatsu so far at my clinic.

The ages of these subjects were as follows: 3 in their 30's, 5 in their 40's, 9 in their 50's, 12 in their 60's, 10 in their 70's, 10 in their 80's and 2 in their 90's. The diseases of subjects were as follows: 18 patients with hypertension (7 males and 11 females), 10 patients with diabetes mellitus (3 males and 7 females), 14 patients with dyslipidemia (4 males and 10 females), and 9 patients with obesity (1 male and 8 females).

The criteria of indication for Kaatsu were as follows:

Hypertension:	Systolic blood pressure, 150 mmHg - 170 mmHg, Diastolic blood pressure, 90 mmHg - 100 mmHg
Diabetes mellitus:	HbA1c levels of 6.5% or above
Dyslipidemia:	LDL cholesterol levels of 140 mg/dl or above
Obesity:	BMI levels of 28 or above

However, patients with a resting blood pressure of 170 / 100 mmHg or above were excluded from the subjects because they could be considered at danger of a rise in pressure during Kaatsu training.

Fasting blood samples were taken early in the morning and body weight was measured with the Body Composition Analyzer MC190 (TANITA Corporation, Tokyo). The kinetics of GH secretion before and after Kaatsu was examined in one elderly patient to confirm the results reported before, since the levels of GH in previous studies were checked only in young athletes (Takarada et al., 2000) or

healthy males (Takano et al., 2006).

Kaatsu training protocols

Before Kaatsu was applied, there was first a 10 minute period of stretching of the entire body. Then, the Kaatsu belts (Sato Sports Plaza, Tokyo) were coiled around the proximal end of either the arms or the legs. After this, the pneumatic control type Kaatsu Training Device (the Kaatsu-Master or the Kaatsu-Mini, Sato Sports Plaza, Tokyo) was connected to those belts, and Kaatsu was performed for a period of 6-12 minutes under an appropriate pressure (60 to 160 mmHg for the arms and 80 to 200 mmHg for the legs respectively). The appropriate pressure was set so as the patients didn't feel pain in the distal portion to the Kaatsu belt during the exercise. The content of Kaatsu was a 3-exercise set of training (Sato Y, 2007a); that is, (1) an opening and shutting movement of both the fingers and the toes at the same time, (2) an extension and a flexion of the arms (arm curl) and the feet (toes raise) at the same time, and (3) a pushing the both fists which are placed in front of the chest down obliquely to behind, with stretching the elbows (push down) and the heels up (calf raise) at the same time. Each 3-exercise set was performed 30 times with 20 second resting intervals. This exercise intensity was equivalent to the Borg scale of level 13 (somewhat hard). Kaatsu was performed once or twice a week.

Evaluation of the effectiveness

For the exact evaluation, the purpose of this study

was sufficiently explained to the patients and they were instructed not to change their lifestyle (food, exercise, and medicine). Nevertheless, some patients changed their lifestyle during this study and they were therefore excluded from the assessment. The evaluation of the effect was done 3 to 4 months later. The criteria of effectiveness were as follows:

- Hypertension: Drop in systolic and diastolic pressure of 10% or above
- Diabetes mellitus: Drop in HbA1c of 10% or above
- Dyslipidemia: Decrease in LDL cholesterol of 8% or above
- Obesity: Weight loss of 10% or above

Statistical methods

All values are expressed as means ± S.D.

RESULTS

There were no accidents in this study.

Effect of Kaatsu on 51 cases with metabolic syndrome (Table 1 and Figure 1)

Kaatsu was effective against metabolic syndrome in 31 patients (61%), and ineffective in 11 patients (22%). A total of 9 patients (17%) were excluded. Among the excluded cases, 6 patients changed their lifestyles during this study; 5 patients added diet or exercise therapy by themselves, seeking further improvement because they had seen the effectiveness of Kaatsu before the evaluation, and a patient had his medical treatment changed by another clinic during

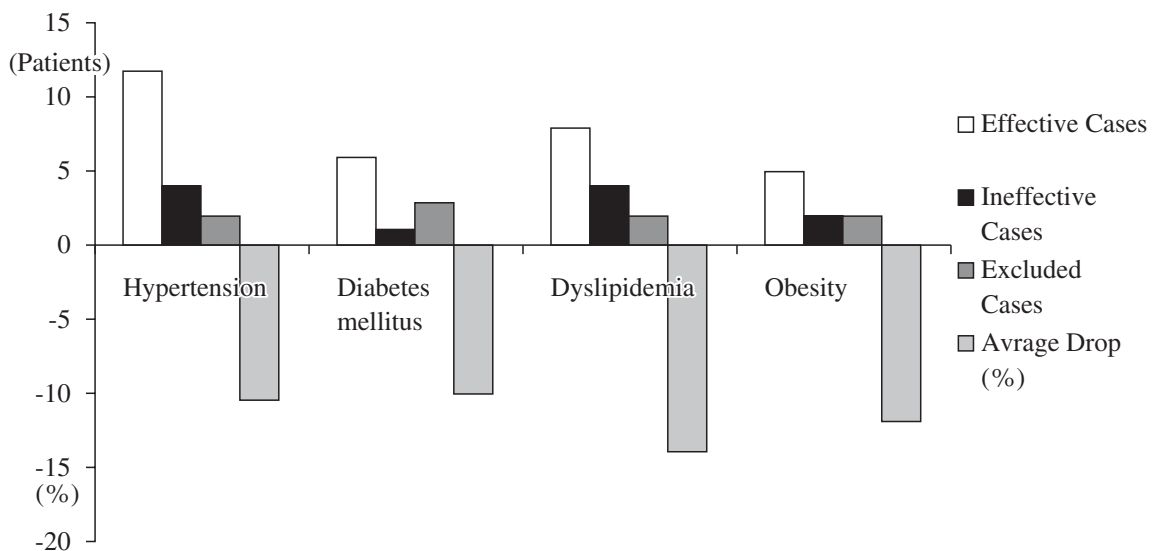


Figure 1. Effectiveness of Kaatsu and average rate of change for each condition (total of 51 Kaatsu patients)

Explanatory Note: See the main text for more details

Kaatsu was effective in 12 out of 18 cases (67%) in the hypertension group: the average drop was -12% for systolic pressure and -10% for diastolic pressure, in 6 out of 10 cases (60%) in the diabetes mellitus: HbA1c dropped by an average of -10%, effective in 8 out of 14 cases (57%) in the dyslipidemia: LDL-c decreased by an average of -14%, and in 5 out of 9 cases (56%) in the obesity: BMI dropped by an average of -12%.

Table 1. Changes of measurement items before and after Kaatsu

Condition (No. of effective cases)	Measurement Item	Before Kaatsu (Average)	After Kaatsu (Average)	Average Drop Rate (%) (Average)
Hypertension (n=12)	systolic pressure (mmHg)	166 ± 5.98	146 ± 1.15	-12 ± 2.87
	diastolic pressure (mmHg)	96 ± 2.68	86 ± 2.88	-10 ± 2.24
Diabetes mellitus (n=6)	HbA1c (%)	6.8 ± 0.31	6.12 ± 0.29	-10 ± 0.56
Dyslipidemia (n=8)	LDL-c (mg/dl)	158 ± 12.60	136 ± 6.99	-14 ± 2.62
Obesity (n=5)	Weight (Kg)	67 ± 4.26	59 ± 3.30	-12 ± 1.91
	BMI	28.7 ± 1.82	25.2 ± 1.41	-12 ± 0.48

All values are expressed as means ± S.D.

the study. Furthermore, 3 patients withdrew themselves from the study because no effects had appeared; 2 patients had diabetes mellitus and the other one had dyslipidemia.

Table 1 and Figure 1 show the results of this study. Kaatsu decreased blood pressure in 12 out of 18 patients with hypertension (67%); In systolic blood pressure, there was an average drop from 166 ± 5.98 mmHg to 146 ± 1.15 mmHg and the average drop rate was -12 ± 2.87%. In diastolic blood pressure, there was an average drop from 96 ± 2.68 mmHg to 86 ± 2.88 mmHg and the average drop rate was -10 ± 2.24%. Among the 2 excluded cases, one patient added walking to his lifestyle by himself and the other patient who attended a different clinic had his medication reduced by the attending physician. Kaatsu was effective in 6 out of 10 patients with diabetes mellitus (60%): HbA1c dropped by an average of 6.8 ± 0.31% to 6.12 ± 0.29% and the average of drop rate was -10 ± 0.56%. There were 3 excluded patients in this group. A patient restricted her eating habits (snacks between meals) by herself and the other 2 patients discontinued Kaatsu 2 months after starting without seeing a drop in HbA1c. Kaatsu was effective in 8 out of 14 patients with dyslipidemia (57%): LDL-c decreased by an average of -14 ± 2.62% in 158 ± 12.60 mg/dl to 136 ± 6.99 mg/dl. Among the 2 excluded patients, one patient restricted her eating habits (snacks between meals) by herself, and the other patient discontinued Kaatsu treatment because LDL-c didn't drop. Kaatsu was also effective in 5 out of 9 patients with obesity (56%): There was an average reduction in body weight from 67 ± 4.26 kg (BMI 28.7 ± 1.82) to 59 ± 3.30 kg (BMI 25.2 ± 1.41) and by an average of -12 ± 1.91 (BMI -12 ± 0.48)%. There were 2 patients excluded

because they restricted their eating habits (snacks between meals).

The measurement of GH

GH was measured before and after Kaatsu in one female patient in her 80's. Her GH levels increased about 11-fold 20 minutes after Kaatsu from 0.24 ng/dl to 2.57 ng/dl as in the same way as previously reported (Takarada et al., 2000; Takano et al., 2005). So it was confirmed that even in the elderly people there was a clear increase of GH by Kaatsu. However, this was only one example.

A case presentation (Table 2)

This is the presentation of a typical case of which a favorable effect was seen from Kaatsu. The case was a female in her 80's, different from the case mentioned above. The patient, who goes to a local clinic on foot with the use of a cane because of her left-side partial paralysis due to a cerebral infarction ten years ago, hypertension and dyslipidemia, visited my clinic for the purpose of strengthening her muscles. Kaatsu was performed twice a week using the Kaatsu-Master (Sato Sports Plaza, Tokyo) for nine minutes with a 3-exercise set of Kaatsu training (Sato Y, 2007) in the seated position at 120 mmHg on her left paralyzed arm and at 110 mmHg on the right. The results were as follows: increases 4.4% of muscle mass, 6.6% of lean body mass, 9% of estimated bone mass, 4% of basal metabolism, 5 kg (50%) of the left hand grip strength, and a 1 second (25%) longer duration of standing on her paralyzed left leg, decreases 9.7% amount of fat, 11% of her body fat percentage, and 14.3% of visceral fat. In addition, there were other improvements with Kaatsu, such as reductions in 13% of systolic and 28 % of diastolic blood pressure,

Table 2. Changes before and after Kaatsu (female, in her 80's)

Item	Before Kaatsu	4 months after Kaatsu (% of change)
Body weight (standard: 45 kg)	45.05 ↑	45.30 (+0.6)
Muscle mass (standard: 29.90 kg)	30.9 ↑	32.25 (+4.4)
Lean body mass (standard: 30.0 %)	32.6 ↑	34.10 (+4.6)
Level of fat (standard: 13.50 kg)	12.4 ↓	11.2 (-9.7)
Body fat percentage (standard: 30.0 %)	27.6 ↓	24.7 (-11.0)
BMI (standard 22.0)	22.0	22.20 (+0.9)
Estimated bone mass	1.70	1.85 (+8.8)
Visceral fat level (10=CT100 cm ²)*	7	6 (-14.3)
Basal metabolism (kcal)	917	950 (+3.4)
Left hand grip (kg)	10	15 (+50)
Left leg standing (seconds)	4	5 (+25)
Blood pressure (135/85 mmHg)	134 / 78	116 / 56 (-13 / -28)
Urea nitrogen** (Normal level 8-22 mg/dl)	22.2 ↑	14.8 (-33)
Total cholesterol** (128-219 mg/dl)	223 ↑	190 (-14.8)
LDL cholesterol** (70-139 mg/dl)	109	82 (25.0)
Blood sugar**	103	99 (-3.9)

Explanatory Note

This case saw an improvement in all items by Kaatsu training.

*The visceral fat level 10 corresponds to 100 cm² of visceral fat from CT.

**150 minutes postprandial values.

a 33% decrease of BUN, 25% decrease in LDL-c, and 3.9% drop in blood glucose as in the Table 2.

DISCUSSION

Kaatsu training

Kaatsu is a unique muscle training method in a condition of hypoxia and an accumulation of metabolites (Sato Y, 2007b). When a special belt is wrapped around the base of the upper or lower limbs and pressure is added followed by a moderate tightening, arterial blood flow peripheral to the belt is slightly reduced, and venous return is markedly reduced. When exercise is performed under such conditions that arteriovenous blood flow is restricted, despite a light burden and short time, not only muscle hypertrophy but also muscle power are increased. The effectiveness of this method is equivalent to or better than conventional muscle training. The principal mechanism of this is believed to be the increase in secretion of bioactive substances, such as GH and insulin-like growth factor-1 (IGF-1) by Kaatsu (Takarada et al., 2000; Abe et al., 2005).

GH

It was recently elucidated that GH not only stimulates the physical growth and development, but it also plays an important role in metabolic regulation in adulthood. In the function of GH there is an anabolic action on cells and an anti-insulin action. The anabolic action is a protein synthesis of the internal organs and an accelerator of cell growth operating through IGF-1 which is produced in the liver. On the other hand, the anti-insulin action is one that is antagonistic to insulin in glucose and lipid metabolism. In glucose metabolism, glucose tolerance is lowered and in lipid metabolism, there is a lipolytic action breaking neutral fat down to free fatty acids and glycerol. These actions maintain the important biological function of protecting against an increase in body fat and also maintain the mass of the cell protein, muscles, organs, and immune systems. Furthermore, it has also been reported that GH maintains psychophysiological health.

The mechanism of Kaatsu effect

In this study, the group that had the highest effect rate of 67% was the hypertension group. The main

causes of antihypertensive mechanism can be explained as follows: (1) The increase of GH/IGF-1 secretion caused by Kaatsu encourages nitric oxide (NO) production which expands the peripheral arteries (Wickman et al., 2002), (2) The reduction of peripheral artery resistance due to IGF-1 production (Copeland and Nair, 1994), (3) The microvessels and capillary vessels distal to the Kaatsu belt are physically dilated by inhibition of venous return (Ishii, 2004), and (4) The cessation of Kaatsu brings a rapid increase of venous return to the heart, and an increased preload to the heart enlarges the atrium and depolarizes the atrial stretch receptors followed by the reduction of peripheral vascular resistance caused by the vagal reflex (Satoh et al., 1975).

The mechanism of the reduction of HbA1c may be due to the following: (1) The improvement of insulin resistance due to the decrease in visceral fat induced by GH (Fowelin et al., 1993; Johannsson et al., 1997). In the initial period of Kaatsu, a transient elevation of blood glucose due to the anti-insulin action of GH is normalized later. In 1997, Johannsson et al. reported that the GH treatment of abdominal obese men increased blood glucose initially and then reduced later. (2) The hypoglycemic action of IGF-1 (Lunds et al., 1994), and (3) GH secretion increases type I muscle fibers which are highly sensitive to insulin (Ayling et al., 1989). Finally, it is expected that long term Kaatsu could bring further muscle hypertrophy and a greater improvement in insulin resistance by increased glucose consumption in the hypertrophied muscles.

In dyslipidemia, the accelerated degradative action of GH may reduce LDL cholesterol (Rudling et al., 1992), and in obesity, GH may induce the lipolytic action (Bengtsson et al., 1993).

There is also a possibility that it may take some time for the production of effect by exercise therapy of dyslipidemia and obesity (Katsukawa, 2006) and so it is essential to obtain the better understanding of the patients .

Somatopause (age-related decline in GH secretion) and the metabolic syndrome

The age-related decline in secretion of various hormones is explained by the concept of pause. Especially, age-related decline in GH secretion is called somatopause. The amount of GH secretion peaks in late adolescence and then declines by about 14% every ten years after that. In elderly people, GH secretion drops to the level in a condition similar to the disease with GH deficiency. As a result, in elderly people, a decrease in GH secretion causes a reduction in muscle and bone mass, visceral obesity and a decline in the quality of life. To make matters worse, this decrease develops the pathological conditions such as hypertension and diabetes mellitus. In 1990,

Rudman et al. hypothesized that the reduction in bone and muscle mass with aging was closely related to a GH deficiency. They subcutaneously administered growth hormone 0.03 mg/kg at a time, 3 times a week for 6 months to 21 healthy elderly men aged 61-81. Despite the fact this dosage was a small amount 1/6 of GH therapy, favorable results were obtained such as an 8.8% increase in muscle mass, a 14.4% decrease in the level of fat, a 1.6% increase in the lumbar vertebrae bone density and a 7.1% increase in skin thickness (Rudman et al., 1993). According to the many additional studies since then, it has been revealed that GH plays an important role not only in the treatment of dwarfism in infant growth hormone deficiency and adult growth hormone deficiency disease (Rosen and Bengtsson, 1990) but also has a role in the promotion of health in healthy adults and control of aging. Based on the result of the effectiveness of Kaatsu in my clinic, it seems that metabolic syndrome is resulted in the condition with GH deficiency. But, further studies are needed to clarify it.

Although GH replacement therapy causes a decrease in body fat and an increase in lean body mass, the effectiveness on strengthening muscle power is uncertain (Paradakakis et al., 1996). In contrast, Kaatsu has been confirmed to be effective in strengthening muscle power in the original studies (Takarada et al., 2000; Ishii, 2004) as well as traditional strength training. The aforementioned female patient in her 80's saw a 5 kg increase in grip strength and a one second extension of the time on one leg standing on the left paralyzed side by Kaatsu. Therefore, it is clear that Kaatsu is superior to GH therapy in a treatment of metabolic syndrome. Furthermore, although it is known that salt and fluid retention is a side effect of GH treatment, there have been no such reports in Kaatsu. In addition, in GH treatment, there are disputes about its safety in relation to the long-term administration of artificial GH biomedicine due to gene recombination. The most serious adverse effects reported are increases in malignancies and early or late mortality in adult age. Conversely, Kaatsu secretes pure natural GH from inside of the body itself and since the amount of secretion is within the range of self-healing capacity, it is very safe.

The essence of the treatment of metabolic syndrome is not losing body weight, but rather reducing fat, especially visceral fat. Even though the weight and lean body weight of the female patient in her 80's described above increased by +0.5% and +4.6% respectively by Kaatsu, the amount of body fat and visceral fat were reduced by -11.0% and -14.3%. This fact surely indicates that Kaatsu is the essential treatment and prevention method for metabolic syndrome. Furthermore,

Kaatsu is a training method that can be performed anywhere by anyone. This is because neither a long period of time nor a wide space is needed as in the traditional muscle training. In addition, it has been reported that for those who are beginners to exercise, GH was secreted in a higher concentration at 80 mmHg of the Kaatsu pressure, 50% below the original Kaatsu pressure, 160 mmHg (Koh et al., 2011). Therefore, Kaatsu is suitable as a resistance therapeutic exercise that is also enough reason for elderly people with no habit of exercise.

CONCLUSION

Kaatsu training was applied to patients with metabolic syndrome over a period of 3 to 4 months and it was effective in 31 out of 51 patients. The highest rate of effectiveness was 67% in the patients with hypertension, followed by 60% in the diabetes mellitus, 57% in the dyslipidemia, and finally 56% in the obesity. This mechanism can be explained by the fact that the secretion of growth hormone / IGF-1 and various bioactive substances by Kaatsu not only reduces fat but participates in anti-hypertension, lowering in blood sugar and reduction in weight. Further studies are needed to clarify this possibility.

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