Paterson DH, Cunningham DA, Koval JJ, St Croix CM (1999) Aerobic fitness in a population of independently living men and women aged 55–86 years. Med Sci Sports Exerc 31:1813–1820

Posner JD, Gorman KM, Klein HS, Cline CJ (1987) Ventilatory threshold: measurement and variation with age. J Appl Physiol 63:1519–1525

Proctor DN, Joyner MJ (1997) Skeletal muscle mass and the reduction of V_{O_2max} in trained older subjects. J Appl Physiol 82:1411–1415

Reimers CD, Harder, T, Saxe H (1998) Age-related muscle atrophy does not affect all muscles and can partly be compensated by physical activity: an ultrasound study. J Neurol Sci 159:60–66

Sanada K, Kuchiki T, Takao Y, Horii M, Kyuunou, S, Hatori Y (1997) References of exercise prescription in ideal old aged that considered to individual differences in fitness levels (in Japanese). Ono Sports Sci 5:71–86

Sanada K, Kearns CF, Kojima K, Abe T (2005) Peak oxygen uptake during running and arm cranking normalized to total and regional skeletal muscle mass measured by magnetic resonance imaging. Eur J Appl Physiol 93:687–693

Sanada K, Kearns CF, Midorikawa, Abe T (2006) Prediction and validation of total and regional skeletal muscle mass by ultrasound in Japanese adults. Eur J Appl Physiol 96:24–31

Song MY, Ruts E, Kim J, Janumala I, Heymsfield S, Gallagher D (2004) Sarcopenia and increased adipose tissue infiltration of muscle in elderly African American women. Am J Clin Nutr 79:874–880

Stathokostas L, Jacob-Johnson S, Petrella RJ, Paterson DH (2004) Longitudinal changes in aerobic power in older men and women. J Appl Physiol 97:781–789

Talbot LA, Metter EJ, Fleg JL (2000) Leisure-time physical activities and their relationship to cardiorespiratory fitness in healthy men and women 18–95 years old. Med Sci Sports Exerc 32:417–425

Tanaka H, Seals DR (2003) Invited review: dynamic exercise performance in Masters athletes: insight into the effects of primary human aging on physiological functional capacity. J Appl Physiol 95:2152–2162

Thomas SG, Cunningham DA, Thompson J, Rechnitzer PA (1985) Exercise training and "ventilation threshold" in elderly. J Appl Physiol 59:1472–1476

Toth MJ, Gardner AW, Ades PA, Poehlman ET (1994) Contribution of body composition and physical activity to age-related decline in peak V_{O_2} in men and women. J Appl Physiol 77:647–652

Tuomainen P, Peuhkurinen K, Kettunen R, Rauramaa R (2005) Regular physical exercise, heart rate variability and turbulence in a 6-year randomized controlled trial in middle-aged men: the DNASCO study. Life Sci 77:2723–2734

Wasserman K, Hansen JE, Sue DY, Stringer WW, Whipp BJ (2005) Principles of exercise testing and interpretation: including pathophysiology and clinical applications. Lippincott Williams & Wilkins, Philadelphia

Zhang JG, Ohta T, Ishikawa-Takata K, Tabata I, Miyashita M (2003) Effects of daily activity recorded by pedometer on peak oxygen consumption (V_{O_2peak}), ventilatory threshold and leg extension power in 30- to 69-year-old Japanese without exercise habit. Eur J Appl Physiol 90:109–113

Short Communication

Comparison of Muscle Strength between Japanese Men with and without Metabolic Syndrome

Nobuyuki Miyatake[a]*, Jun Wada[b], Takeshi Saito[a], Hidetaka Nishikawa[a],
Sumiko Matsumoto[a], Motohiko Miyachi[c], Hirofumi Makino[b],
and Takeyuki Numata[a]

[a]*Okayama Southern Institute of Health, Okayama 700-0952, Japan,*
[b]*Department of Medicine and Clinical Science, Okayama University Graduate School of
Medicine, Dentistry and Pharmaceutical Sciences, Okayama 700-8558, Japan, and*
[c]*National Institute of Health and Nutrition, Shinjuku, Tokyo 162-8636, Japan*

We compared muscle strength between Japanese men with and without metabolic syndrome. We used data for 323 Japanese men with metabolic syndrome and 893 Japanese men without the syndrome. Metabolic syndrome was defined by a new criterion in Japan, and the parameters for muscle strength, *i.e.* grip strength, leg strength were measured. Leg strength was found to be significantly higher in subjects with metabolic syndrome than in those without, while muscle strength per body weight was significantly lower in subjects with the syndrome. Lower muscle strength per body weight may be one of the characteristic features in subjects with metabolic syndrome.

Key words: metabolic syndrome, grip strength, leg strength

M etabolic syndrome is a common disorder and has become a public challenge in Japan. For example, 30.7% of men and 3.6% of women have been diagnosed as having metabolic syndrome using the new criterion in Japan [1]. The metabolic syndrome has been associated with an increased risk of cardiovascular disease [2], proteinuria [3], and elevation of hepatic enzymes [4]. Lifestyle modifications, especially exercise, are important for preventing and improving metabolic syndrome. However, the link between metabolic syndrome using the new criterion in Japan and muscle strength remains to be investigated. In this study, we compared muscle strength between Japanese men with and without metabolic syndrome.

Subjects and Methods

Subjects. We used the data for 1,216 Japanese men, aged 20-79 years, who met the following criteria, 1) received annual health checkups from June 1997 to May 2005 at Okayama Southern Institute of Health, 2) received fasting blood examination and muscle strength measurements, and 3) obtained written informed consent.

Anthropometric measurements. Anthropometric parameters *i.e.* height, weight, and waist circumference were measured. The waist circumference was measured at the umbilical level.

Definition of metabolic syndrome. Meta-

bolic syndrome was defined, among men with a waist circumference in excess of 85 cm, as having 2 or more components from the following: 1) Dyslipidemia: triglycerides $\geq$ 150 mg/dl and/or HDL cholesterol < 40 mg/dl, 2) High blood pressure: blood pressure $\geq$ 130/85 mmHg, 3) Impaired glucose tolerance: fasting plasma glucose $\geq$ 110 mg/dl [5].

Measurements of muscle strength. To assess muscle strength, grip and leg strength were measured. Grip strength was measured by using THP-10 (SAKAI, Tokyo, Japan), while leg strength was measured by COMBIT CB-1 (MINATO, Osaka, Japan). Isometric leg strength was measured as follows: the subject sat in a chair, grasping the armrest in order to fix the body position. The dynamometer was then attached to the subject's ankle joint by a strap. They next extended the leg to 60 degrees [6]. In addition, to standardize the influence of the total body weight, we calculated the muscle strength (kg) per body weight (kg) [7].

Statistical analysis. Data are expressed as mean ± standard deviation (SD) values. A comparison of parameters between the 2 groups was made using the unpaired t-test and covariance analysis: $p < 0.05$ was considered to be statistically significant.

Results

A total of 323 men (26.6%) were diagnosed as having metabolic syndrome, and the measurements of muscle strength in subjects with and without metabolic syndrome (n = 893) are indicated in the Table. The age was significantly higher in subjects with metabolic syndrome and thus, to avoid the influence of age on muscle strength, we used the age as a covariate and compared the muscle strength using covariance analysis. In subjects with metabolic syndrome, leg strength was significantly higher compared with subjects without metabolic syndrome. However, muscle strength per body weight was significantly lower in subjects with metabolic syndrome.

We then analyzed the groups with and without each component of metabolic syndrome. The age was significantly higher in subjects with abdominal obesity, impaired glucose tolerance, dyslipidemia, and high blood pressure compared with the subjects with-

out each component. Based on the comparison of muscle strength adjusting for age, leg strength was significantly higher in subjects with abdominal obesity, dyslipidemia, and high blood pressure. In subjects with impaired glucose tolerance, leg strength was significantly lower than in subjects without impaired glucose tolerance. In subjects with abdominal obesity, the left grip strength was significantly higher compared with subjects without abdominal obesity. However, the leg strength per body weight in subjects with abdominal obesity was significantly lower. In addition, the grip strength per body weight in subjects with abdominal obesity, dyslipidemia, and high blood pressure was also significantly lower.

Discussion

We compared muscle strength in metabolic syndrome men with that in non-metabolic syndrome men using the criterion in Japan.

In some literature, cardiorespiratory fitness is closely associated with metabolic syndrome [8, 9]. However, the relationship between muscle strength and metabolic syndrome, especially using the new criterion in Japan, has not been clearly investigated. Jurca R *et al.* have reported examining the associations for muscle strength and cardiorespiratory fitness with the prevalence of metabolic syndrome by cross sectional [10] and longitudinal study [11]. They concluded that muscle strength has an inverse association with metabolic syndrome prevalence using the National Cholesterol Education Program (NCEP) definition. In this study, by using the new criterion in Japan, leg strength was found to be significantly higher in subjects with metabolic syndrome than in those without the syndrome. However, muscle strength per body weight was significantly lower in subjects with metabolic syndrome than that in those without the syndrome. Leg strength per body weight in subjects with abdominal obesity was significantly lower, and grip strength per body weight in subjects with abdominal obesity, dyslipidemia, and high blood pressure was also significantly lower. These findings may stress the clinical significance of such components on muscle strength per body weight in subjects with metabolic syndrome. Although aerobic exercise has been advocated as the most suitable exercise for metabolic syndrome, it is difficult for subjects with

Table 1   Comparison of parameters between subjects with and without metabolic syndrome

	Mean ± SD		p Unpaired t test	p Adjusting for age
	Metabolic syndrome (+)	Metabolic syndrome (−)		
Number of subjects	323	893		
Age	49.4 ± 11.0	45.4 ± 12.5	< 0.0001	
Right grip strength (kg)	44.3 ± 8.2	43.7 ± 8.4		0.3232
Left grip strength (kg)	42.3 ± 8.0	41.9 ± 7.6		0.1779
Leg strength (kg)	67.8 ± 17.7	65.2 ± 17.0		0.0016
Right grip strength(kg)/body weight(kg)	0.56 ± 0.10	0.65 ± 0.12		< 0.0001
Left grip strength(kg)/body weight(kg)	0.54 ± 0.10	0.62 ± 0.11		< 0.0001
Leg strength(kg)/body weight(kg)	0.86 ± 0.20	0.96 ± 0.22		0.0058
	Waist circumference (+)	Waist circumference (−)		
Number of subjects	600	616		
Age	47.6 ± 11.1	45.3 ± 13.1	0.0013	
Right grip strength (kg)	45.0 ± 8.3	42.7 ± 8.3		0.2376
Left grip strength (kg)	43.1 ± 7.8	40.9 ± 7.5		0.0130
Leg strength (kg)	69.0 ± 17.2	62.9 ± 16.6		0.0002
Right grip strength(kg)/body weight(kg)	0.58 ± 0.10	0.67 ± 0.12		< 0.0001
Left grip strength(kg)/body weight(kg)	0.55 ± 0.11	0.64 ± 0.11		< 0.0001
Leg strength(kg)/body weight(kg)	0.88 ± 0.20	0.99 ± 0.23		< 0.0001
	Impaired glucose tolerance (+)	Impaired glucose tolerance (−)		
Number of subjects	282	934		
Age	51.5 ± 10.7	44.9 ± 12.2	< 0.0001	
Right grip strength (kg)	41.7 ± 8.0	44.5 ± 8.3		0.0553
Left grip strength (kg)	39.9 ± 7.9	42.6 ± 7.6		0.1340
Leg strength (kg)	62.7 ± 17.7	66.9 ± 16.9		0.0221
Right grip strength(kg)/body weight(kg)	0.58 ± 0.11	0.64 ± 0.12		0.1935
Left grip strength(kg)/body weight(kg)	0.56 ± 0.11	0.61 ± 0.11		0.0565
Leg strength(kg)/body weight(kg)	0.87 ± 0.21	0.95 ± 0.22		0.4832
	Dyslipidemia (+)	Dyslipidemia (−)		
Number of subjects	577	639		
Age	47.6 ± 11.7	45.4 ± 12.6	0.0014	
Right grip strength (kg)	43.2 ± 8.5	44.4 ± 8.1		0.3572
Left grip strength (kg)	41.5 ± 8.0	42.4 ± 7.5		0.2205
Leg strength (kg)	65.3 ± 17.8	66.4 ± 16.6		0.0155
Right grip strength(kg)/body weight(kg)	0.60 ± 0.11	0.65 ± 0.11		0.0034
Left grip strength(kg)/body weight(kg)	0.57 ± 0.11	0.62 ± 0.11		0.0055
Leg strength(kg)/body weight(kg)	0.90 ± 0.22	0.97 ± 0.22		0.3452
	High blood pressure (+)	High blood pressure (−)		
Number of subjects	703	513		
Age	48.9 ± 11.8	43.1 ± 11.9	< 0.0001	
Right grip strength (kg)	43.7 ± 8.4	44.0 ± 8.2		0.2065
Left grip strength (kg)	42.0 ± 8.0	42.0 ± 7.4		0.0843
Leg strength (kg)	65.9 ± 17.7	65.9 ± 16.5		0.0001
Right grip strength(kg)/body weight(kg)	0.61 ± 0.11	0.65 ± 0.12		0.0006
Left grip strength(kg)/body weight(kg)	0.58 ± 0.11	0.62 ± 0.11		0.0020
Leg strength(kg)/body weight(kg)	0.91 ± 0.22	0.97 ± 0.22		0.8945

lower leg strength per body weight to support their entire body weight, and it is also difficult to carry out aerobic exercise i.e. walking and jogging. In addition, resistance training increases muscle quantity and insulin action [12, 13] and reduces visceral adipose tissue [14]. These findings suggest that resistance exercise training should be considered in primary prevention of metabolic syndrome.

Potential limitations remain in our study. First, the cross-sectional study design in our study makes it difficult to infer causality between metabolic syndrome and muscle strength. Second, although reductions in basal leg blood flow [15] and resting metabolic rate [16] have been implicated in the pathogenesis of metabolic syndrome, we could not prove the mechanism of the link between metabolic syndrome and muscle strength. Therefore, our findings are applicable to clinical and public health practice settings. In conclusion, lower muscle strength per body weight is characteristic in Japanese men with metabolic syndrome. Further intervention studies are necessary to test the effects of the prevention and treatment of metabolic syndrome.

References

1. Miyatake N, Kawasaki Y, Nishikawa H, Takenami S and Numata T: Prevalence of metabolic syndrome in Okayama prefecture, Japan. Intern Med (2006) 45: 107–108.
2. Wilson PW, Kannel WB, Silbershatz H and D'Agostino RB: Clustering of metabolic factors and coronary heart disease. Arch Intern Med (1999) 159: 1104–1109.
3. Miyatake N, Wada J, Kawasaki Y, Matsumoto S, Makino H and Numata T: Relationship between metabolic syndrome and proteinuria in the Japanese population. Intern Med (2006) 45: 599–603.
4. Miyatake N, Matsumoto S, Makino H and Numata T: Comparison of hepatic enzymes between Japanese men with and without metabolic syndrome. Acta Med Okayama (2007) 61: 31–34
5. Definition and the diagnostic standard for metabolic syndrome-Committee to evaluate diagnostic standards for metabolic syndrome. Nippon Naika Gakkai Zasshi (2005) 94: 794–809 (in Japanese).
6. Kigawa A, Yamamoto T, Koyama Y, Kageyama S and Arima K: Evaluation of knee extensor strength for prevention of sports injury. Japan Ortho Soc Sports Med (1987) 6: 141–145 (in Japanese):
7. Miyatake N, Takahashi K, Wada J, Nishikawa H, Morishita A, Suzuki H, Kunitomi M, Makino H, Kira S and Fujii M: Changes in serum leptin concentrations in overweight men after exercise. Diabetes Obes Metab (2004) 6: 332–337.
8. Laaksonen DE, Lakka HM, Salonen JT, Niskanen LK, Rauramaa R and Lakka T: Low levels of leisure-time physical activity and cardiorespiratory fitness predict development of the metabolic syndrome. Diabetes Care (2002) 25: 1612–1618.
9. Katzmarzyk PT, Lenon AS, Wilmore JH, Skinner JS, Rao DC, Rankinen T and Bouchard C: Targeting the metabolic syndrome with exercise: evidence from the HERITAGE Family Study. Med Sci Sports Exerc (2003) 35: 1703–1709.
10. Jurca R, Lamonte MJ, Church TS, Earnest CP, Fitzgerald SJ, Barlow CE, Jordan AN, Kampert JB and Blair SN: Associations of muscle strength and fitness with metabolic syndrome in men. Med Sci Sports Exerc (2004) 36: 1301–1307.
11. Jurca R, lamonte MJ, Barlow CE, Kampert JB, Church TS and Blair SN: Association of muscular strength with incidence of metabolic syndrome. Med Sci Sports Exerc (2005): 37: 1849–1855.
12. Andersen JL, Schjerling P, Andersen LL and Dela F: Resistance training and insulin action in humans: effects of de-training. J Physiol (2003) 551: 1049–1058.
13. Holten MK, Zacho M, Gaster M, Juel C, Wojtaszewski JF and Dela F: Strength training increases insulin-mediated glucose uptake, GLUT4 content, and insulin signaling in skeletal muscle in patients with type 2 diabetes. Diabetes (2004) 294–305.
14. Park SK, Park JH, Kwon YC, Kim HS, Yoon MS and Park HT: The effect of combined aerobic and resistance exercise training on abdominal fat in obese middle-aged women. J Physiol Anthoropol Appl Human Sci (2003) 22: 129–135.
15. Miyachi M, Tanaka H, Kawano H, Okajima M and Tabata I: Lack of age-related decreases in basal whole leg blood flow in resitance-trained men. J Appl Physiol (2005) 99: 1384–1390.
16. Toth MJ and Poehlman ET: Resting metabolic rate and cardiovascular disease risk in resistance- and aerobic-trained middle-aged women. Int J Obes Relat Metab Disord (1985) 19: 691–698.

Comparison of ventilatory threshold and exercise habits between Japanese men with and without metabolic syndrome

Nobuyuki Miyatake [a,*], Takeshi Saito [a], Jun Wada [b], Motohiko Miyachi [c], Izumi Tabata [c], Sumiko Matsumoto [a], Hidetaka Nishikawa [a], Hirofumi Makino [b], Takeyuki Numata [a]

[a] Okayama Southern Institute of Health, 408-1 Hirata, Okayama 700-0952, Japan
[b] Department of Medicine and Clinical Science, Okayama University Graduate School of Medicine, Dentistry and Pharmaceutical Sciences, Okayama, Japan
[c] National Institute of Health and Nutrition, Shinjuku, Tokyo, Japan

Abstract

Objective: We compared the levels of ventilatory threshold (VT) and exercise habits in subjects with metabolic syndrome with those in age, sex-matched subjects without metabolic syndrome.

Methods: We used data of 155 Japanese men (47.1 $\pm$ 9.2 years) with metabolic syndrome; the diagnosis was given by the definition and the diagnostic standard for metabolic syndrome in Japan. The influence of metabolic syndrome on oxygen uptake, work rate and heart rate at VT, and exercise habits were evaluated.

Results: Oxygen uptake and work rate at VT in subjects with metabolic syndrome were significantly lower than those in subjects without metabolic syndrome even after adjusting for body mass index (BMI). The number of subjects with exercise habits was significantly lower in metabolic syndrome. The subjects with exercise habits were significantly older than that in subjects without exercise habits. Furthermore, oxygen uptake and work rate at VT were significantly higher in subjects with exercise habits than those in subjects without exercise habits.

Conclusion: Lower level of VT was characteristic in subjects with metabolic syndrome. Promotion of exercise habits is necessary for preventing and improving metabolic syndrome in Japanese men.
© 2006 Elsevier Ireland Ltd. All rights reserved.

Keywords: Metabolic syndrome; Ventilatory threshold; Exercise habits

1. Introduction

Metabolic syndrome is characterized by abdominal obesity, high blood pressure, dyslipidemia and impaired glucose tolerance [1]. New criterion in Japan has been defined in April 2005 and 30.7% in men and 3.6% in women are diagnosed as having metabolic syndrome using the new criterion in Japan [1,2]. Exercise is considered as a useful method for preventing metabolic syndrome and improving each component of metabolic syndrome. The ventilatory threshold (VT) is defined as the upper limit of the aerobic exercise and is thought to serve as an accurate and reliable standard for exercise prescription [3]. Since the exercise intensity at VT is not harmful to cardiovascular function, it can be safely applied to patients with myocardial infarction as exercise prescription [4]. However, the relationship

---

* Corresponding author. Tel.: +81 86 246 6250;
fax: +81 86 246 6331.
E-mail address: center@okakenko.jp (N. Miyatake).

between exercise habits and metabolic syndrome, also between physical fitness such as aerobic exercise level defined by VT and metabolic syndrome using the new criterion in Japan are not fully discussed.

In this study, we evaluated the parameters at VT and exercise habits between Japanese men with and without metabolic syndrome.

2. Subjects and methods

2.1. Subjects

The total number of Japanese men with metabolic syndrome, aged 24–68 years, was 155 and they were enrolled into annual health check-ups at Okayama Southern Institute of Health with written informed consent. They were compared with 115 men who were age and sex matched and without metabolic syndrome.

2.2. Anthropometric measurements

The anthropometric measurements were performed by using the following parameters such as height, body weight, body mass index (BMI) and waist circumference. BMI was calculated by weight/[height]^2 (kg/m^2). The waist circumference was measured at the umbilical level [5].

2.3. Blood pressure measurements

Blood pressure of each participant was measured after resting at least 15 min in the sitting position.

2.4. Blood sampling and assays

We measured overnight fasting serum levels of high density lipoprotein (HDL) cholesterol, triglycerides (L Type Wako Triglyceride H, Wako Chemical, Osaka) and plasma glucose.

2.5. Definition of metabolic syndrome

The syndrome was defined [1], among men with a waist circumference in excess of 85 cm and women with a waist circumference in excess of 90 cm [6], as having 2 or more components from among the following: (1) dyslipidemia: triglyceride $\geq$ 150 mg/dl and/or HDL cholesterol $\geq$ 40 mg/dl, (2) high blood pressure: blood pressure $\geq$ 130/85 mmHg, (3) impaired glucose tolerance: fasting plasma glucose $\geq$ 110 mg/dl.

2.6. Exercise testing

A graded ergometer exercise protocol [7] was performed. Two hours after breakfast, a resting ECG was recorded and blood pressure was measured. Then, all participants were given graded exercise after 3 min of pedaling on an unloaded

bicycle ergometer (Excalibur V2.0, Lode BV, Groningen, Netherlands). The profile of incremental workloads was automatically defined by the methods of Jones [7], in which the workloads reach the predicted $\dot{V}O_2$ max in 10 min. A pedaling cycle of 60 rpm was maintained. Loading was terminated when the appearance of symptoms forced the subject to stop. During the test, ECG was monitored continuously together with the recording of heart rate (HR). Expired gas was collected and rates of oxygen consumption ($\dot{V}O_2$) and carbon dioxide production ($\dot{V}CO_2$) were measured breath-by-breath using a cardiopulmonary gas exchange system (Oxycon Alpha, Mijnhrdt b.v., Netherlands). VT was determined by the standard of Wasserman et al. [3], Davis et al. [8], and the V-slope method of Beaver [9] from $\dot{V}O_2$, $\dot{V}CO_2$ and minute ventilation ($\dot{V}E$). At VT, $\dot{V}O_2$ (ml/(kg min)), work rate (W), and heart rate (beats/min) were measured and recorded.

2.7. Exercise habits

The data on exercise habits were obtained at interviews by well-trained staff in a structured way according to the National Nutrition Survey in Japan [10]. The subjects were asked if they currently exercise (over the level of 30 min per session, two times per week and prolonged duration for 3 months). When the answer was "yes", they were classified as subjects with exercise habits. When the answer was "no", they were classified as subjects without exercise habits.

2.8. Statistical analysis

Data are expressed as mean $\pm$ standard deviation (S.D.) values. Relationship between metabolic syndrome and exercise habits was tested using χ^2-test and comparison of parameters between two groups was used by unpaired t-test: $P < 0.05$ was considered to be statistically significant.

3. Results

Table 1 shows the comparison of age, body weight, BMI and parameters at VT between subjects with metabolic ($n = 155$) and without metabolic syndrome ($n = 155$). There was no significant difference of age between the subjects with and without metabolic syndrome. Oxygen uptake at VT and work rate at VT in subjects with metabolic syndrome was significantly lower than those in subjects without metabolic syndrome. Heart rate at VT in subjects with metabolic syndrome was similar to that in subjects without metabolic syndrome.

We also compared the levels of parameters at VT between the groups with and without each component of definition of metabolic syndrome in Japan (Table 2). Of 310 subjects, 56 subjects were diagnosed as having type 2 diabetes mellitus (fasting plasma glucose

Table 1

Comparison of parameters at VT between metabolic and non-metabolic subjects in men

	Metabolic syndrome (+)	Metabolic syndrome (−)
Number of subjects	155	155
Age	47.1 ± 9.2	47.1 ± 9.2
Body weight (kg)	80.6 ± 12.4	72.9 ± 11.1[a]
BMI (kg/m²)	28.0 ± 3.6	25.6 ± 3.4[a]
Oxygen uptake at VT (ml/(kg min))	14.2 ± 2.7	16.1 ± 3.6[a]
Work rate at VT (W)	75.6 ± 17.1	80.7 ± 22.5[b]
Heart rate at VT (beat/min)	105.1 ± 12.3	106.5 ± 11.3

VT: ventilatory threshold, BMI: body mass index.

[a] $P < 0.01$ vs. metabolic syndrome (+).

[b] $P < 0.05$ vs. metabolic syndrome (+).

≤ 126 mg/dl). There was no significant difference of age between subjects with or without abdominal obesity or dyslipidemia and high blood pressure. However, there was a significant difference of age between subgroups with or without impaired glucose tolerance. Oxygen uptake at VT in subjects with abdominal obesity, dyslipidemia, impaired glucose tolerance and high blood pressure were significantly lower than those in subjects without such components of metabolic syndrome. Work rate at VT and heart rate at VT in subjects with impaired glucose tolerance were also significantly lower than those in subjects without impaired glucose tolerance. In addition, we compared the levels of parameters at VT between the groups with and without various combinations of each component (Table 2). Oxygen uptake at VT in subjects with two or

Table 2

Comparison of parameters at VT with and without subcriterion of metabolic syndrome in men

	Waist circum ference (+)	Waist circum ference (−)
Number of subjects	243	67
Age	47.0 ± 8.9	47.5 ± 10.0
Oxygen uptake at VT (ml/(kg min))	14.4 ± 2.7	17.8 ± 3.8[a]
Work rate at VT (W)	78.1 ± 19.3	78.4 ± 23.0
Heart rate at VT (beat/min)	105.2 ± 11.9	108.0 ± 11.3
	Dyslipidemia (+)	Dyslipidemia (−)
Number of subjects	175	135
Age	46.4 ± 8.8	48.0 ± 9.6
Oxygen uptake at VT (ml/(kg min))	14.7 ± 3.1	15.7 ± 3.6 a
Work rate at VT (W)	76.5 ± 18.5	80.3 ± 21.9
Heart rate at VT (beat/min)	106.0 ± 12.0	105.4 ± 11.6
	Impaired glucose tolerance (+)	Impaired glucose tolerance (−)
Number of subjects	112	198
Age	49.5 ± 9.0	45.8 ± 9.0[a]
Oxygen uptake at VT (ml/(kg min))	14.1 ± 2.7	15.7 ± 3.5[a]
Work rate at VT (W)	73.8 ± 16.6	80.7 ± 21.5[a]
Heart rate at VT (beat/min)	104.0 ± 11.4	106.8 ± 12.0[b]
	High blood pressure (+)	High blood pressure (−)
Number of subjects	231	79
Age	47.6 ± 8.9	45.7 ± 9.8
Oxygen uptake at VT (ml/(kg min))	14.8 ± 3.0	16.2 ± 3.9[a]
Work rate at VT (W)	77.8 ± 19.6	79.2 ± 21.5
Heart rate at VT (beat/min)	105.1 ± 11.8	107.7 ± 11.6
	Dyslipidemia (+) and impaired glucose tolerance (+)	Dyslipidemia (−) and/or impaired glucose tolerance (−)
Number of subjects	67	243
Age	47.8 ± 8.8	46.9 ± 9.3
Oxygen uptake at VT (ml/(kg min))	14.0 ± 2.8	15.4 ± 3.4[a]
Work rate at VT (W)	74.9 ± 18.6	79.1 ± 20.4
Heart rate at VT (beat/min)	105.8 ± 11.3	105.8 ± 12.0

Table 2 (Continued)

	Dyslipidemia (+) and high blood pressure (+)	Dyslipidemia (−) and/or high blood pressure (−)
Number of subjects	142	168
Age	46.6 ± 8.8	47.5 ± 9.5
Oxygen uptake at VT (ml/(kg min))	14.6 ± 2.9	15.6 ± 3.6[a]
Work rate at VT (W)	75.8 ± 17.8	80.2 ± 21.7
Heart rate at VT (beat/min)	105.6 ± 12.3	105.9 ± 11.5
	High blood pressure (+) and impaired glucose tolerance (+)	**High blood pressure (−) and/or impaired glucose tolerance (−)**
Number of subjects	89	221
Age	49.4 ± 8.8	46.2 ± 9.1[a]
Oxygen uptake at VT (ml/(kg min))	14.2 ± 2.7	15.5 ± 3.5[a]
Work rate at VT (W)	75.6 ± 16.1	79.2 ± 21.5
Heart rate at VT (beat/min)	104.6 ± 11.1	106.2 ± 12.1
	Dyslipidemia (+) and high blood pressure (+) and impaired glucose tolerance (+)	**Dyslipidemia (−) and/or high blood pressure (−) and/or impaired glucose tolerance (−)**
Number of subjects	54	256
Age	47.8 ± 8.7	47.0 ± 9.3
Oxygen uptake at VT (ml/(kg min))	14.3 ± 2.7	15.3 ± 3.4[b]
Work rate at VT (W)	76.6 ± 17.6	78.5 ± 20.6
Heart rate at VT (beat/min)	106.0 ± 11.0	105.7 ± 12.0

VT: ventilatory threshold.

[a] $P < 0.01$ vs. (+).

[b] $P < 0.05$ vs. (+).

three components was significantly lower than that the subjects without one of these components.

To avoid the influence the BMI on VT, we compared the parameters at VT in obese (BMI ≥ 25) metabolic syndrome subjects with those in obese non-metabolic syndrome subjects (Table 3). There were no significant differences of age and BMI between the subjects with and without metabolic syndrome. Oxygen uptake and work rate at VT in obese men with metabolic syndrome

Table 3
Comparison of parameters at VT between metabolic and non-metabolic subjects in obese (|BMI| ≥ 25) men

	Metabolic syndrome (+)	Metabolic syndrome (−)
Number of subjects	130	87
Age	46.7 ± 9.3	46.2 ± 8.1
BMI (kg/m²)	28.7 ± 3.4	27.9 ± 2.3
Oxygen uptake at VT (ml/(kg min))	14.0 ± 2.5	14.8 ± 2.6[b]
Work rate at VT (W)	76.2 ± 15.5	84.3 ± 21.7[a]
Heart rate at VT (beat/min)	105.1 ± 12.1	104.9 ± 10.8

VT: ventilatory threshold, BMI: body mass index.

[a] $P < 0.01$ vs. metabolic syndrome (+).

[b] $P < 0.05$ vs. metabolic syndrome (+).

were significantly lower than those in obese men without metabolic syndrome.

We evaluated the relationship between metabolic syndrome and exercise habits. Of 310 men, 116 men (37.4%) were classified as having exercise habits. The prevalence of metabolic syndrome in subjects with exercise habits (42.2%) was significantly lower than that in subjects without exercise habits (54.6%) (Table 4).

Finally, we compared the parameters at VT between subjects with and without exercise habits (Table 5). Age in subjects with exercise habits was significantly higher than that in subjects without exercise habits. However, oxygen uptake and work rate at VT were significantly higher in subjects with exercise habits than those in subjects without exercise habits.

Table 4
Relationship between metabolic syndrome and exercise habits in men

	Metabolic syndrome (+)	Metabolic syndrome (−)
Exercise habits (+)	49	67
Exercise habits (−)	106	88

$P < 0.05$ by χ^2-test.

Table 5
Comparison of parameters at VT between subjects with and without exercise habits in men

	Exercise habits (+)	Exercise habits (−)
Number of subjects	116	194
Age	48.5 ± 8.7	46.3 ± 9.3[b]
Oxygen uptake at VT (ml/(kg min))	15.9 ± 3.9	14.7 ± 2.8[a]
Work rate at VT (W)	81.8 ± 23.5	76.0 ± 17.5[b]
Heart rate at VT (beat/min)	105.6 ± 11.4	105.9 ± 12.1

VT: ventilatory threshold.
[a] $P < 0.01$ vs. exercise habits (+).
[b] $P < 0.05$ vs. exercise habits (+).

4. Discussion

Our study is the first report on the relationship between metabolic syndrome, defined by the new criterion of metabolic syndrome in Japan, and exercise habits and the levels of VT. Metabolic syndrome has important clinical and public health implications because it is a common disorder in Japan [1,2]. Previous studies documented that metabolic syndrome is an important risk factor for diabetes, coronary heart disease and stroke [11–13]. Our study shows new and important information about the relationship between metabolic syndrome, and exercise habits and oxygen uptake at VT in Japanese men.

The prevalence of subjects with exercise habits in Japan was reported to be 29.3% in men and 24.1% in women by the National Nutrition Survey in Japan [10] and our results were not similar and the prevalence of subjects with exercise habits was higher than that in the previous study. Definition of prolonged time in our study was shorter and, in addition, enrolled subjects in our study were undertook annual health check-ups and they might therefore be more careful of their own health than subjects in the National Nutrition Survey.

Regular physical activity has been linked to increases in HDL and reductions in resting blood pressure, triglycerides, abdominal fat, fating glucose levels, and insulin responses to oral glucose challenge [14–16]. In several reports in the cross sectional study, metabolic syndrome was significantly correlated with physical fitness [17–19]. However, the hypothesis that metabolic syndrome may be caused by lower oxygen uptake at VT cannot be proven in our current cross-sectional design. The Kuopio Ischemic Heart Disease Risk Factor Study [20] followed several hundred men who did not have metabolic syndrome at baseline. Four years later, subjects in the upper one-third of VO_2max at baseline were 75% less likely than unfit men to develop

metabolic syndrome. Katzmarzyk et al. reported that the effects of 20 weeks supervised aerobic training program on the prevalence of the metabolic syndrome in 621 men and women who were enrolled in the Heritage Study. After exercise intervention, 30.5% of the participants with metabolic syndrome at baseline were no longer classified as having metabolic syndrome [21]. Ekelund et al. reported that physical activity energy expenditure predicts progression toward the metabolic syndrome independent of aerobic fitness, obesity, and other confounding factors by observation of 5.6 years [22]. In our study, oxygen uptake at VT in men with metabolic syndrome was significantly lower than that in men without metabolic syndrome, even after adjusting for BMI. Oxygen uptake at VT in subjects with sub criterion of metabolic syndrome was also significantly lower than that in subjects without sub criterion of metabolic syndrome. In addition, the number of subjects with exercise habits was significantly lower in metabolic syndrome and the subjects with exercise habits had higher oxygen uptake at VT. It may be hard to clarify the mechanisms as to why the exercise habits are linked to higher oxygen uptake at VT and beneficial for preventing the metabolic syndrome. Although the mechanism is not well-understood, we previously reported that the education program, in which we instructed overweight Japanese men to increase daily step per day and join a weekly exercise course, resulted in increased oxygen uptake at VT and reduced visceral fat area [5].

Our study has potential limitation. First, our study was a cross-sectional and not a longitudinal training study. Second, we could not accurately prove the mechanism between lower oxygen uptake at VT and metabolic syndrome. However, it seems reasonable to suggest that simply moving from the lower oxygen uptake at VT to higher oxygen uptake at VT might result in the amelioration of the metabolic syndrome in some Japanese men. Therefore, we need promote exercise habits for preventing and improving metabolic syndrome. Further prospective studies are needed in Japanese using the new criterion of Japan.

Acknowledgement

References

[1] Definition and the diagnostic standard for metabolic syndrome— Committee to Evaluate Diagnostic Standards for Metabolic

Syndrome, Nippon Naika Gakkai Zasshi 94 (2005) 794–809 (in Japanese).

[2] N. Miyatake, Y. Kawasaki, H. Nishikawa, S. Takenami, T. Numata, Prevalence of metabolic syndrome in Okayama prefecture, Japan, Intern. Med. 45 (2006) 107–108.

[3] K. Wasserman, B.J. Whipp, S.N. Koyl, W.L. Beaver, Anaerobic threshold and respiratory gas exchange during exercise, J. Appl. Physiol. 35 (1973) 236–243.

[4] K.T. Weber, J.S. Janicki, Cardiopulmonary exercise testing for evaluation of chronic cardiac failure, Am. J. Cardiol. 55 (1985) 22–31.

[5] N. Miyatake, J. Wada, K. Takahashi, H. Nishikawa, A. Morishita, H. Suzuki, et al., Changes in serum leptin concentrations in overweight Japanese men after exercise, Diabetes Obes. Metab. 6 (2004) 332–337.

[6] The Examination Committee of Criteria for 'Obesity Disease' in Japan; Japan Society for the Study of Obesity, New criteria for 'obesity disease' in Japan, Circ. J. 66 (2002) 987–992.

[7] N.L. Jones, L. Makrides, C. Hitchcock, T. Chypchar, N. McCartney, Normal standards for an incremental progressive cycle ergometer test, Am. Rev. Respir. Dis. 131 (1985) 700–708.

[8] J.A. Davis, M.H. Frank, B.J. Whipp, K. Wasserman, Anaerobic threshold alterations caused by endurance training in middle-aged men, J. Appl. Physiol. 46 (1979) 1039–1046.

[9] W.L. Beaver, K. Wasserman, B.J. Whipp, A new method for detecting anaerobic threshold by gas exchange, J. Appl. Physiol. 60 (1986) 2020–2027.

[10] The National Nutrition Survey in Japan, Available from http://www.mhlw.go.jp/houkoku/2005/04/h0421-1b.html (accessed June 1, 2006) (in Japanese).

[11] S.M. Haffner, R.A. Valdez, H.P. Hazuda, B.D. Mitchell, P.A. Morales, M.P. Stern, Prospective analysis of the insulin-resistance syndrome (syndrome X), Diabetes 41 (1992) 715–722.

[12] B. Isomaa, P. Almgren, T. Tuomi, B. Forsen, K. Lahti, M. Nissen, et al., Cardiocascular morbidity and mortality associated with the metabolic syndrome, Diabetes Care 24 (2001) 683–689.

[13] H.M. Lakka, D.E. Laaksonen, T.A. Lakka, L.K. Niskanen, E. Kumpusalo, J. Tuomilehto, et al., The metabolic syndrome and total and cardiovascular disease mortality in middle-aged men, JAMA 288 (2002) 2709–2716.

[14] N. Miyatake, K. Takahashi, J. Wada, H. Nishikawa, A. Morishita, H. Suzuki, et al., Daily exercise lowers blood pressure and reduces visceral fat in overweight Japanese men, Diabetes Res. Clin. Pract. 62 (2003) 149–157.

[15] N. Miyatake, H. Nishikawa, A. Morishita, M. Kunitomi, J. Wada, H. Suzuki, et al., Daily walking reduces visceral adipose tissue areas and improves insulin resistance in Japanese obese subjects, Diabetes Res. Clin. Pract. 58 (2002) 101–107.

[16] R.J. Barnard, E.J. Ugianskis, D.A. Martin, S.B. Inkeles, Role of diet and exercise in the management of hyperinsulinemia and associated atherosclerotic risk factors, Am. J. Cardiol. 69 (1992) 440–444.

[17] S. Caroll, C.B. Cooke, R.J. Butterly, Metabolic clustering, physical activity and fitness in non smoking, middle-aged men, Med. Sci. Sports Exerc. 32 (2000) 2079–2086.

[18] I.J. Kullo, D.D. Hensrud, T.G. Allison, Relation of low cardiorespiratory fitness to the metabolic syndrome in middle-aged men, Am. J. Cardiol. 90 (2002) 795–797.

[19] M. Nagano, Y. Kai, B. Zou, T. Hatayama, M. Suwa, H. Sasaki, et al., The contribution of cardiorespiratory fitness and visceral fat to the risk factors in the Japanese patients with impaired glucose tolerance and type 2 diabetes mellitus, Metabolism 53 (2004) 644–649.

[20] D.E. Laaksonen, H.M. Lakka, J.T. Salonen, L.K. Niskanen, R. Rauramaa, T. Lakka, Low levels of leisure-time physical activity and cardiorespiratory fitness predict development of the metabolic syndrome, Diabetes Care 25 (2002) 1612–1618.

[21] P.T. Katzmarzyk, A.S. Lenon, J.H. Wilmore, J.S. Skinner, D.C. Rao, T. Rankinen, et al., Targeting the metabolic syndrome with exercise: evidence from the Heritage Family Study, Med. Sci. Sports Exerc. 35 (2003) 1703–1709.

[22] U. Ekelund, S. Brage, P.W. Franks, S. Hennings, S. Emms, N.J. Wareham, Physical activity energy expenditure predicts progression toward the metabolic syndrome independently of aerobic fitness in middle-aged healthy Caucasians: the Medical Research Council Ely Study, Diabetes Care 28 (2005) 1195–1200.

Relationship between Changes in Body Weight and Waist Circumference in Japanese

Nobuyuki MIYATAKE[1], Sumiko MATSUMOTO[1],
Motohiko MIYACHI[2], Masafumi FUJII[3] and Takeyuki NUMATA[1]

[1]Okayama Southern Institute of Health, Okayama Health Foundation, Okayama, Japan
[2]National Institute of Health and Nutrition, Tokyo, Japan
[3]Department of Health Care Medicine, Kawasaki Medical School, Kurashiki, Japan

Short Communication

Relationship between Changes in Body Weight and Waist Circumference in Japanese

Nobuyuki MIYATAKE[1], Sumiko MATSUMOTO[1],
Motohiko MIYACHI[2], Masafumi FUJII[3] and Takeyuki NUMATA[1]

[1]*Okayama Southern Institute of Health, Okayama Health Foundation, Okayama, Japan*
[2]*National Institute of Health and Nutrition, Tokyo, Japan*
[3]*Department of Health Care Medicine, Kawasaki Medical School, Kurashiki, Japan*

Abstract

Objectives: We investigated the correlation between changes in body weight and body composition parameters.

Methods: We used the data of 2635 Japanese (40.2±12.2 years) at baseline and at 1-year follow-up from a database of 13522 subjects, which is available at the Okayama Southern Institute of Health in Okayama prefecture, Japan. Body weight, waist circumference at the umbilical level, hip circumference, and body fat percentage were used in the analyses.

Results: Body composition parameters were significantly reduced after 1 year. Changes in body weight significantly correlated with changes in waist circumference, changes in hip circumference, and changes in body fat percentage. A decrease in body weight of 3 kg corresponded to a 3.45 cm decrease in waist circumference in men and a 2.83 cm decrease in that in women.

Conclusion: A decrease in body weight of 3 kg corresponded to an almost 3 cm decrease in waist circumference at the umbilical level in Japanese men and women.

Key words: body weight, waist circumference, hip circumference, body fat percentage

Introduction

Metabolic syndrome has become a public health issue in Japan (1). For example, 30.7% of men and 3.6% of women are diagnosed as having metabolic syndrome (2), and reducing visceral fat is considered to be a critical therapeutic approach (1). In 2006, a 3 kg decrease in body weight and a 3 cm decrease in waist circumference were recommended by the Japan Society for the Study of Obesity (JASSO) (http://wwwsoc.nii.ac.jp/jasso/, accessed on Jan 25, 2007) for the prevention and alleviation of metabolic syndrome. However, the link between changes in body weight and waist circumference still remains to be investigated. Therefore, we evaluated how changes in body weight correlate with changes in body composition parameters, namely, waist circumference, hip circumference, and body fat percentage, using baseline and 1-year follow-up data of a large sample of the Japanese population, which is available at the Okayama Southern Institute of Health in Okayama prefecture, Japan.

Subjects and Methods

Subjects

We used the retrospective data of 2635 Japanese (40.2±12.2 years) from a database of 13522 subjects (42.5±14.9 years) who underwent an annual health check-up from June 1997 to March 2005 at the Okayama Southern Institute of Health in Okayama prefecture, Japan, for the purpose of improving their lifestyle. The selected 2635 subjects met the following criteria: (1) underwent an annual baseline health check-up from June 1997 to March 2005, (2) underwent an annual health check-up after 1 year, (3) received no medication for diabetes, hypertension, or dyslipidemia, and (4) provided written informed consent (Table 1).

At the annual health check-up, all the subjects were instructed by well-trained medical staff to change their lifestyle according to the results.

Approval for the study was obtained from the Ethical Committee of the Okayama Health Foundation.

Anthropometric and body composition measurements

Anthropometric and body compositions were evaluated on the basis of the following parameters: height, body weight, waist circumference, hip circumference, and body fat percentage (3). The waist circumference was measured at the umbilical level, and the hip was measured at the widest circumference over the trochanter in standing subjects after normal expiration as previously described (1, 3). Body fat percentage was measured using an air displacement plethysmograph called the BOD POD Body Composition System (Life Measurement Instruments, Concord, CA, USA) (4, 5). The coefficient variation (CV: %) for same-day tests was 2.48, that for three separate-day tests was 2.27, and that for independent operators was 4.53. There was a clear correlation between the results from BOD POD and those from dual-energy X-ray absorptiometry (DEXA) (r=0.910, $p<0.01$) (4).

Statistical analysis

All data are expressed as mean±standard deviation (SD). Statistical analysis was performed using the paired *t* test: $p<0.05$ was considered to be statistically significant. Relationships of the parameters of interest were determined by univariate regression analysis. Pearson's correlation coefficients were calculated and used to test the significance of the linear relationship among continuous variables.

Results

Clinical parameters at baseline (1997–2005) and at 1-year follow-up (1998–2006) are summarized in Table 1. At 1-year follow-up, anthropometric and body composition parameters, namely, body weight, waist circumference, hip circumference, and body fat percentage were significantly reduced.

We investigated the correlation between body weight and body composition parameters at baseline (1997-2005) by simple correlation analysis (Table 2). Body weight significantly correlated with these parameters in both sexes. In addition, changes in body weight also significantly correlated with the changes in waist circumference, hip circumference, and body fat percentage in both sexes (Table 3, Fig. 1). Furthermore, the slopes of the regression line (change in waist circumference vs change in body weight) for men and women were 1.069 and

Table 1 Clinical parameters at baseline (1997–2005) and at 1-year follow-up (1998–2006)

	Baseline	Follow-up	*p*
Total			
Number of subjects	2635		
Age	40.2±12.2		
Body weight (kg)	60.1±12.0	59.7±11.9	<0.0001
Waist circumference (cm)	74.9±10.7	74.5±10.5	<0.0001
Hip circumference (cm)	92.1±6.0	91.8±5.9	<0.0001
Body fat percentage (%)	28.1±7.3	27.4±7.4	<0.0001
Men			
Number of subjects	856		
Age	39.4±12.1		
Body weight (kg)	70.4±11.0	70.1±11.1	0.0015
Waist circumference (cm)	83.1±9.6	82.4±9.5	<0.0001
Hip circumference (cm)	94.3±5.8	94.1±5.7	0.0020
Body fat percentage (%)	23.6±6.6	22.8±6.6	<0.0001
Women			
Number of subjects	1779		
Age	40.6±12.2		
Body weight (kg)	55.1±5.6	54.7±8.6	<0.0001
Waist circumference (cm)	71.0±8.7	70.6±8.7	0.0001
Hip circumference (cm)	91.0±5.7	90.7±5.7	<0.0001
Body fat percentage (%)	30.2±6.6	29.6±6.7	<0.0001

Mean±SD

Table 2 Simple correlation analysis between body weight and body composition parameters at baseline (1997–2005)

	r	*p*
Total		
Waist circumference (cm)	0.894	<0.0001
Hip circumference (cm)	0.864	<0.0001
Body fat percentage (%)	0.176	<0.0001
Men		
Waist circumference (cm)	0.856	<0.0001
Hip circumference (cm)	0.938	<0.0001
Body fat percentage (%)	0.567	<0.0001
Women		
Waist circumference (cm)	0.848	<0.0001
Hip circumference (cm)	0.912	<0.0001
Body fat percentage (%)	0.631	<0.0001

Table 3 Univariate regression and correlaion analyses between changes in (delta) body weight and body composition parameters in 856 men and 1779 women aged 14–77 years from 1997–2005 and 1998–2006

	r	*p*	Regression formula	y	x
Total					
Delta waist circumference (cm)	0.734	<0.0001	y=1.002x−0.062	Delta waist circumference	Delta body weight
Delta hip circumference (cm)	0.739	<0.0001	y=0.667x−0.038	Delta hip circumference	Delta body weight
Delta body fat percentage (%)	0.670	<0.0001	y=0.764x−0.403	Delta body fat percentage	Delta body weight
Men					
Delta waist circumference (cm)	0.794	<0.0001	y=1.069x−0.243	Delta waist circumference	Delta body weight
Delta hip circumference (cm)	0.742	<0.0001	y=0.557x−0.066	Delta hip circumference	Delta body weight
Delta body fat percentage (%)	0.699	<0.0001	y=0.767x−0.425	Delta body fat percentage	Delta body weight
Women					
Delta waist circumference (cm)	0.689	<0.0001	y=0.950x+0.018	Delta waist circumference	Delta body weight
Delta hip circumference (cm)	0.749	<0.0001	y=0.752x−0.012	Delta hip circumference	Delta body weight
Delta body fat percentage (%)	0.649	<0.0001	y=0.761x−0.392	Delta body fat percentage	Delta body weight
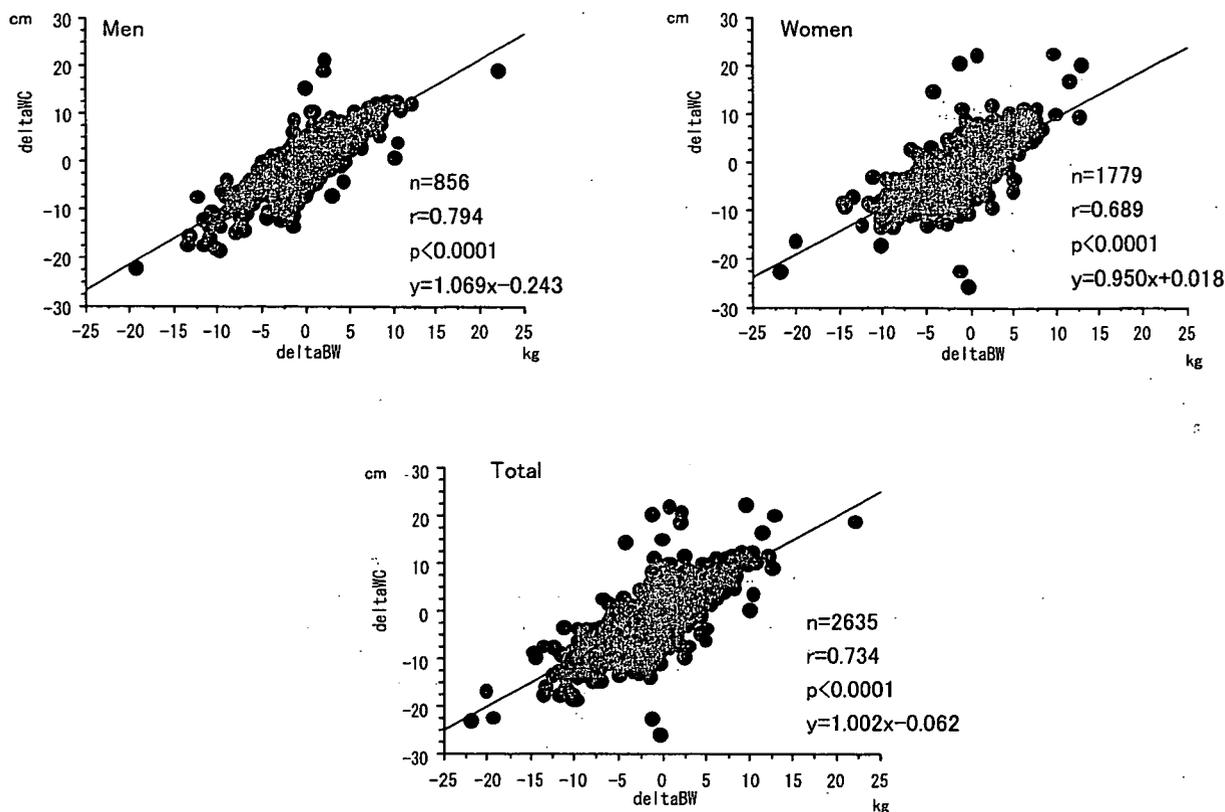
Fig. 1 Univariate regression and correlation analyses of changes in (delta) body weight and waist circumference. BW: body weight, WC: waist circumference.

0.950, respectively (Table 3). Accordingly, we found that a 3 kg decrease in body weight, as recommended by JASSO, corresponded to a 3.45 cm decrease in waist circumference in men and a 2.83 cm decrease in that in women (Fig. 1).

Discussion

The main finding of this study is that a 3 kg decrease in body weight corresponded to an almost 3 cm decrease in waist circumference at the umbilical level after 1 year.

There are few studies on the correlation between change in body weight and change in waist circumference using a large sample of the population. Egger et al. reported that a 1 cm decrease in waist circumference was equivalent to a decrease of about 3/4 kg, but with wide variability, in a study involving 42 retired Caucasian men and 45 indigenous men from Northern Australia who participated in a 1–2 year waist circumference loss program (6). We previously reported that the 1-year weight loss program, in which we instructed 61 overweight Japanese men to increase their number of daily steps per day and join a weekly exercise course, resulted in a 3.3 kg decrease in body weight and a 4.2 cm decrease in waist circumference (7). In this study, we used a large sample of the Japanese population, and body weight significantly correlated with body composition parameters. The average body fat percentage in men (23.6± 6.6%) was lower than that in women (30.2±6.6%). Therefore, the correlation coefficient between body weight and body fat percentage in all the subjects was comparatively lower than that in men and women at the baseline. In addition, a 3 kg decrease

in body weight corresponded to an almost 3 cm decrease in waist circumference, which agreed with the JASSO recommendation.

Potential limitations still remain in this study. First, although we confirmed the correlation between changes in body weight and changes in waist circumference, we could not provide the threshold of body weight and waist circumference reduction for preventing and alleviating metabolic syndrome. Second, we neither directly measured the visceral fat accumulation using computed tomography nor investigated the correlation between visceral fat accumulation and body composition parameters. Third, the 13522 subjects in our study voluntarily underwent the annual health check-up; they were therefore more health-conscious than the average person. The selected 2635 subjects underwent an annual health check-up every year with a follow-up duration of 1 year and received no medication; they were therefore more health-conscious than most of the subjects in the database. They were also instructed by well-trained medical staff to change their lifestyle, and as a result their anthropometric and body composition parameters were significantly reduced.

Further intervention studies using other populations are necessary to determine the effects of prevention and treatment on metabolic syndrome.

Acknowledgement

References

(1) Definition and the diagnostic standard for metabolic syndrome-Committee to evaluate diagnostic standards for metabolic syndrome. Nippon Naika Gakkai Zasshi. 2005;94:794–809. (Article in Japanese)

(2) Miyatake N, Kawasaki Y, Nishikawa H, Takenami S, Numata T. Prevalence of metabolic syndrome in Okayama prefecture, Japan. Intern Med. 2006;45:107–108.

(3) Miyatake N, Nishikawa H, Morishita A, Kunitomi M, Wada J, Suzuki H, et al. Daily walking reduces visceral adipose tissue areas and improves insulin resistance in Japanese obese subjects. Diabetes Res Clin Pract. 2002;58:101–107.

(4) Miyatake N, Nonaka K, Fujii M. A new air displacement plethysmograph for the determination of Japanese body com-position. Diabetes Obes Metab. 1999;1:347–351.

(5) McCrory MA, Gomez TD, Bernauer EM, Mole PA. Evaluation of a new air displacement plethysmograph for measuring human body composition. Med Sci Sports Exerc. 1995;27: 1686–1691.

(6) Egger G, Dobson A. Clinical measures of obesity and weight loss in men. Int J Obes Relat Metabl Disord. 2000;24:354–357.

(7) Miyatake N, Wada J, Takahashi K, Nishikawa H, Morishita A, Suzuki H, et al. Changes in serum leptin concentrations in overweight Japanese men after exercise. Diabetes Obes Metab. 2004;6:332–337.

Original Article
Study Design of the Saku Control Obesity Program (SCOP)

Shaw Watanabe [1], Akemi Morita [1], Naomi Aiba [1], Motohiko Miyachi [1], Satoshi Sasaki [1], Masahiro Morioka [2], Masahiko Noda [3], Toru Takebayashi [4], Mitsuru Kimira [5] for SCOP

1) National Institute of Health and Nutrition
2) Saku Central Hospital Health Dock Center
3) National Medical Center
4) School of Medicine, Keio University
5) Tokyo University of Agriculture

Abstract

BACKGROUND: The increasing number of patients with metabolic syndrome and resultant diabetes mellitus, hypertension, hyperlipidemia, and other lifestyle-related diseases are an urgent focus of the Ministry of Health, Labor and Welfare. Because obesity is a common basis of these diseases, the control of obesity is an important aim.

METHODS: A cognitive-behavioral treatment is being employed in a randomized intervention trial at the Saku Health Dock Center. 976 people whose BMI in upper quintile were identified from the health checkup database, and 235 people participated in the Saku Control Obesity Program (SCOP). Various biomarkers (including lipokines and single nucleotide polymorphism SNPs), physical activity, personality type (measured by the NEO-FFI), and dietary habits and dietary intake behavior (measured by the SQ-DHQ) will be measured to clarify the multiple factors influencing obesity. Each participant will use a diary to record body weight, body fat, number of steps, physical activity energy expenditure (PAEE), and success in achieving the established plan; a dietary record and appropriate equipment are also provided. At 1, 3, 6, 9, and 12 months, each participant will be interviewed by a doctor and dietician and receive individual education regarding physical activity. Follow-up will occur 1 and 2 years after baseline measurements.

RESULTS: A total of 116 men (52.9 ± 6.6 years) and 119 women (54.4 ± 6.5 years) are participating in the study. Average body weight (± SD) was 86.4 ± 11.8 kg in males and 75.2 ± 9.5 in females. BMI was 30.4 ± 3.5 in males and 31.1 ± 3.1 in females. Waist and visceral fat area were 101.5 ± 8.7 cm and 159 ± 54 cm^2 in males and 103.7 ± 8.3 cm and 130 ± 47 cm^2 in females, respectively. PAEE was 271 ± 127 kcal in males and 246 ± 102 kcal in females. Basal metabolic rate, measured in one-tenth of the participants, was 1659 ± 226 kcal in males and 1477 ± 210 kcal in females.

CONCLUSION: The purpose of this study is to evaluate the effectiveness of a cognitive-behavioral treatment designed to help obese patients lose weight and to maintain their weight losses over time. SCOP has been started with a good participation rate.

KEY WORDS: obesity, intervention trial, epidemiology, health education

Introduction

The increasing number of patients with metabolic syndrome and resultant lifestyle-related diseases is an urgent issue in Japan, as well as many other developed countries.[1] Many serious medical conditions have been linked to obesity, including type 2 diabetes, hypertension, hyperlipidemia, and cardiovascular diseases.[2] Obesity is also linked to higher rates of certain types of cancer, including colon, rectal, and prostate in males and breast, uterine, and ovarian in females.[3] Because obesity is a common basis of these diseases, controlling obesity is an important means of prevention.

Although unhealthy diet and physical inactivity can cause or aggravate obesity, the increase in obesity over the past 30 years has been fueled by a complex interplay of environmental, social, economic, and behavioral factors, acting on a background of genetic susceptibility.[4,5] The medical community has recognized the extraordinary difficulties in the prevention and treatment of obesity.

Shaw Watanabe, M.D. / National Institute of Health and Nutrition
1-23-1 Toyama, Shinjuku, Tokyo 162-8636, Japan
Tel: +81-3-3203-5721 / Fax: +81-3-3203-5662 / E-mail: watashaw@nih.go.jp

Excess abdominal fat is an important and independent risk factor for disease. Research has shown that waist circumference is directly associated with abdominal fat and can be used in the assessment of risks associated with excess weight and obesity.[6,7] Men with a waist measurement of more than 85 cm and women with a waist measurement of more than 90 cm may have more health risks than people with smaller waist measurements. In recent years, abdominal computed tomography has become available to determine the amount of abdominal fat directly.

Regular physical activity is a key part of any weight-control effort.[8,9] For people who are overweight, increasing physical activity helps them to reduce many of the risks for illnesses associated with obesity. However, the imbalance between caloric intake and expenditure likely differs from one person to another, with genetic, environmental, and other factors all playing a part.[1] Environmental factors include lifestyle behaviors such as what a person eats and his or her level of physical activity. Studies have shown that obese people tend to consume large meals and high-fat foods and place taste and convenience ahead of nutrition. Also, most obese people do not get enough physical exercise.

Obese people may suffer emotionally due to their excessive weight, because they are perceived by others as gluttonous, lazy, or both. As a result, people who are obese often face prejudice or discrimination in social situations. While mediated by underlying personality, feelings of rejection, shame, or depression may occur in obese individuals.[10] In addition to these social influences, behavioral outcomes may have both molecular and environmental influences as well.

High blood pressure, high LDL cholesterol levels, low HDL cholesterol levels, high triglycerides, and high blood glucose are all warning signs of some obesity-associated diseases. Fortunately, people who have a BMI of 30 or greater can improve their health through losing weight.[11] A loss of 5–10% of initial body weight can do much to improve health by lowering blood pressure and other risk factors for obesity-related diseases.[1-3] In addition, research showed that a 5–7% weight loss brought about by moderate diet and exercise could delay or possibly prevent type 2 diabetes in people at high risk of developing the disease. In a recent study, participants who were overweight and had prediabetes were able to delay or prevent the onset of type 2 diabetes by adopting a low-fat, low-calorie diet and exercising for 30 minutes a day, 5 days a week.[12]

Since 1990 a population-based Japan Public Health Center cohort study, consisting of 40- to 59-year-old residents, has been conducted in Saku.[13,14] The purpose of this cohort study was to identify cancer and cardiovascular disease risks, and it represented a novel approach that incorporated biological markers as health screening data and blood storage for future analyses. We selected this area because of a long collaborative history for primary prevention of chronic diseases.

The primary aim of the present study was to reduce the body weight of obese people who have sought weight-loss treatment. To do so, a cognitive-behavioral treatment was implemented as the most promising approach.[15] Compared to a standard behavioral weight loss program, this treatment was specifically designed to target weight reduction and sustained weight loss, as well as improved physical, psychological, and social well-being in participants. This multidisciplinary approach for reducing obesity can be applied by various agencies.

Subjects and Methods

A cognitive-behavioral treatment is being employed for a randomized intervention trial in Saku Health Dock Center.[6] Each year about 7,000 examinees came to the center for health checkups, including an oral glucose tolerance test (OGTT) by 75 g glucose intake. Including all visits, the Saku Health Dock Center database contains approximately 196,000 records. We used the database to select initial examination records, and about 45,000 examinees were identified. For this study, the candidates from recent 5 years was selected with the inclusion criteria of age 40–64 years and a body mass index (BMI: kg/m²) within the upper five percentile (28.3). Exclusion criteria were psychiatric conditions or physical conditions (i.e., significant hepatic or renal dysfunction and significant cardiovascular disease such as heart failure, stroke, and transient ischaemic attacks) that would preclude full participation in the study; current treatment for obesity; current treatments known to affect eating or weight (e.g., medications). A total of 976 people whose BMI was more than 28.3 (upper five percentile) were identified in the health checkup database, and 235 participants were enrolled in the Saku Control Obesity Program (SCOP). The research plan was approved by the Ethical Committee of the National Institute of Health and Nutrition and Saku Central Hospital. Participants received a precise explanation of the study and gave written informed consent.

For two weeks before the baseline survey, every subject wore a uniaxial accelerometer (Lifecorder, Suzuken) all day long, and the calculated physical activity energy expenditure (PAEE) served as the baseline for physical activity training. All participants were randomly divided to two groups: group A will receive intervention in year 1 and be followed up in years 2 and 3; group B will receive intervention in year 2 and be followed up in year 3.

The aim of this study is to reduce body weight 1–2 kg per month. In order to achieve an α error < 0.05 and β error < 0.80, the necessary number of participants in one arm would be 23 if the average group A weight loss was 10 kg from 80 kg and the average group B weight loss was 4 kg, whereas 74 participants would be necessary in each arm if group A lost 10 kg on average and group B lost 5 kg. Thus, the inclusion of more than 100 participants in each arm should provide sufficient statistical power.

At the time of the baseline health checkup, each participant completes a questionnaire regarding health state, smoking and drinking habits, dietary habit, profession, daily life habits, and reproductive history for females. Answers were evaluated by dietitians, who also conduct a baseline interview with each participant.

Various blood and biochemical markers, including lipokines and SNPs, are collected at baseline and at 3, 6, 9, and 12 months during the intervention period. Physical activity is measured continuously by the accelerometer. To clarify the multiple behavioral factors influencing obesity, psychological characteristics are assessed using the NEO-FFI and dietary habits and dietary intake behavior are measured by the SQ-DHQ questionnaire.[16,17]

A diary to record body weight, body fat, number of steps, and success in achieving the established plan (e.g., not eating snacks, increase of 3,000 steps/day), as well as a dietary record are given to each participant. Appropriate equipment, such as body weight and body fat scale and accelerometer (Lifecorder), are also provided.

Intervention, including doctor's interview, dietitian's interview, and individual education regarding dietary habit and physical activity, is scheduled at 1, 3, 6, 9, and 12 months from the baseline. Group A will have a follow-up period of 2 years, and group B will be followed up for 1 year. Longer follow-up data will be obtained from Saku Health Dock Center.

Medical outcomes will include anthropometric and metabolic parameters, and psychosocial outcomes will include obesity-specific quality of life, eating improvement, body satisfaction, mood change (POMS), and cognitive disturbance (QOL).

Blood samples (10 ml) are collected at the time of each health checkup at the Saku Health Dock Center. Routine laboratory blood and urine analyses are performed in the Saku Central Hospital. Frozen plasma and 5 ml of whole blood are sent to the National Institute for Health and Nutrition for lipokine measurement and SNPs analysis.[18]

Follow-up system

All participants will send their diary each month to the National Institute of Health and Welfare. Dietitians will check the body weight change, physical activity, and meals in the record and send comments to encourage the participants. Any health conditions are described in the diary. Doctors confirm participants' health state at each 3-month checkup.

After each checkup, laboratory data are added to the baseline data. In addition, changes of address are reported to the governing committee office in the National Institute of Health and Nutrition, so that new addresses can be added to the master files.

Health education

Active health education was planned according to the cognitive-behavioral treatment.[15] The method of treatment for each participant depends on his or her level of obesity and overall health condition. Treatment includes a combination of diet, exercise, and behavior modification. Previously overweight and obese individuals are encouraged to get 60 to 90 minutes of exercise a day to sustain weight loss. Details of the methods are described in a separate paper.[19]

Data analyses

Basic analyses for the collected questionnaires were done by combining all data obtained at the basal survey. Data-linkage groups were set to link appropriate follow-up data, including the baseline questionnaire, changes of address, incidence of diseases, death, and laboratory data. Each questionnaire was input into an Excel file (Microsoft, Redmond, WA, USA), and all data were combined in an SPSS database (SPSS Ver 14.0, SPSS Inc., Chicago, IL, USA).

Results

Subjects

Since 1986, the number of people who received a health checkup at the Saku Health Dock Center was 44,874 (27,167 males; 17,707 females), with approximately 196,000 total records. To establish a retrospective prospective cohort, a database was made by combining all these annual data. Body weight had been recorded in 44,870 people (27,165 males; 17,705 females) in which the number within the upper five percentile (BMI ≥ 28.3) was 2,247 (1,366 males; 881 females). We selected 976 (612 males; 364 females) obese candidates from the cases up to 2000, whose age was from 40 to 64 years.

The plan of SCOP was introduced by a mailing to these 976 people, and an explanatory meeting was held in the auditorium at Saku Central Hospital. The final number of participants was 116 males and 119 females, aged 52.9 ± 6.6 and 54.4 ± 6.5 years, respectively. Average body weight (± SD) was 86.4 ± 11.8 kg in males and 75.2 ± 9.5 in females. BMI was 30.4 ± 3.5 in males and 31.1 ± 3.1 in females. Waist and visceral fat area were 101.5 ± 8.7 cm and 159.0 ± 54.1cm^2 in males and 103.7 ± 8.3 cm and 129.8 ± 47.0 cm^2 in females, respectively. PAEE was 271 ± 127 kcal in males and 246 ± 102 kcal in females. Basal metabolic rate, measured in one-tenth of the participants, was 1659 ± 226 kcal in males and 1477 ± 210 kcal in females.

At the baseline survey, the prevalence of hypertension was 70.0% in males and 68.1% in females, diabetes mellitus was 40.5% in males and 40.3% in females, and dyslipidemia was 62.1% in males and 45.4% in females. The prevalence of metabolic syndrome was 62.9% in males and 51.3% in females. Other baseline data are described elsewhere.[20] Some of them are summarized in Table 1 (Table 1).

Table 1   Basic Characteristics of the Subjects

Measurement	Men (n = 116)	Women (n = 119)
Age (years)	52.9 ± 6.6	54.4 ± 6.5
Height (cm)	168.4 ± 5.8	155.4 ± 5.5 *
Weight (kg)	86.4 ± 11.8	75.2 ± 9.5 *
BMI (kg/m^2)	30.4 ± 3.5	31.1 ± 3.1
Waist circumference (cm)	101.5 ± 8.7	103.7 ± 8.3 *
Visceral fat area (cm^2)	159 ± 54.1	129.8 ± 47.0 *
Number of steps	7601 ± 3300	8015 ± 3127
PAEE (kcal)	271 ± 127	246 ± 102 *
Adjusted PAEE (METs·h/wk)	3.02 ± 1.43	3.15 ± 1.35

PAEE, physical-activity-related energy expenditure; METs, metabolic equivalents; PA, physical activity

Discussion

Life expectancy is rapidly increasing in Japan, and it has become a national concern how to build a vivid society for aged people. Since the 1980s, the leading causes of deaths have changed from infectious diseases to chronic noncommunicable diseases, such as cancer and cardiovascular diseases, and the past decade has seen an epidemic increase of obesity and diabetes mellitus in Japan.[5] Scientific data, however, are insufficient to make appropriate guidelines for disease prevention. Because cancer and cardiovascular diseases share common causal factors, comprehensive guidelines are needed to prevent both types of diseases. Obesity has risen to epidemic levels in Japan as well as in the United States and other developed countries, causing devastating and costly health problems and reduced life expectancy.[1,2,5] Multiple factors contribute to obesity, ranging from inherent biological traits relevant to body weight that differ between individuals to environmental and socioeconomic factors.

Community-based strategies to increase physical activity levels through the Healthy Japan 21 campaign have not succeeded, according to the midterm analysis, suggesting that psychological and genetic factors should be combined with health education.[21] A psychological approach has not been employed previously in an obesity intervention study in Japan. In this intervention trial, a cognitive-behavioral treatment is being employed, including nonfamily social support and individually adapted health behavior changes.[19] A support team consisting of doctors, dietitians, physical instructors, and nurses work with

participants on dietary and exercise plans as well as an appropriate goal weight. Each participant receives an individualized dietary plan, and a healthy lifestyle guide is included in the diary, which also has a full description of how to use the plan.

In the U.S. Weight Watchers program, the initial focus is on a 10% reduction in body weight.[22] Once the participants reach that goal, they receive instruction and encouragement for continued weight loss. Once they reach their proper, healthy weight, the focus moves to maintenance. The importance of behavior changes for losing weight and keeping it off has been widely recognized. Changing one's lifestyle requires more than choosing different foods and adding more physical activity to the daily routine. It also involves changing a person's approach to eating and activity, which means changing how one thinks, feels, and acts. Research has demonstrated that several tools and tips are effective in helping enact these changes. For instance, people hoping to lose weight should motivate themselves, make lifestyle changes a priority, have a plan, set small goals, and surround themselves with good examples, such as real-life stories, healthy and simple recipes, exercise tips, and interesting facts about fitness. They should avoid food triggers, keep a record, focus on the positive, and try not to give up.

We noted a high prevalence of hypertension, hyperlipidemia, and type 2 diabetes mellitus among the obese people in this study. Most participants with these conditions did not recognize that they were ill, and many felt that prescription drugs alone could alleviate these conditions. However, discussions with doctors about the disease history and explanation of abdominal computed tomography results served as a good motivation for participants to lose weight and add more physical activity to their daily routines.

People who are obese may be able to reverse an earlier metabolic syndrome by adopting a healthy lifestyle and losing weight. Dietary restriction or exercise alone, without weight loss, does not appear to be enough to improve cardiovascular function.[23] Most studies set a tentative goal of 5% reduction of body weight. In contrast, the goal of the SCOP trial is for each participant to lose 10 kg, and improvement of health is expected.

References

1) World Health Organization. Obesity: Preventing and managing the global epidemic. WHO technical report series 894. Geneva, 2000.

2) Hill JO, Peters JC. Environmental contributions to the obesity epidemic. Science 280:1371-1374, 1998.

3) Watanabe S. Cancer of Japanese. Kanehara Shuppan, Tokyo, 1996. (in Japanese)

4) McCurry J. Japan battles with obesity. Lancet 369:451-452, 2007.

5) Yoshiike N, Kaneda F, Takimoto H. Epidemiology of obesity and public health strategies for its control in Japan. Asia Pac J Clin Nutr 11 (Suppl. 8):S727-S731, 2002.

6) Yoshiike N, Seino F, Tajima S, et al. Twenty-year changes in the prevalence of overweight in Japanese adults: the National Nutrition Survey 1976-95. Obes Rev 3:183-190, 2002.

7) Fujioka S, Matsuzawa Y, Tokunaga K, et al. Contribution of intra-abdominal fat accumulation to the impairment of glucose and lipid metabolism in human obesity. Metabolism 36:54-59, 1987.

8) U.S. Department of Health and Human Services. Physical Activity and Health: A Report of the Surgeon General. Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, 1996. Available at www.cdc.gov/nccdphp/sgr/sgr.htm.

9) Centers for Disease Control and Prevention. Risk Factors for Meeting Recommended Guidelines for Moderate Physical Activity. Behavioral Risk Factor Surveillance System, 2003. Available at http://apps.nccd.cdc.gov/brfss/

10) Faith M, Flint J, Fairburn C, et al. Gender differences in the relationship between personality dimensions and relative body weight. Obes Res 9:647-650, 2001.

11) Anderson JW, Konz EC, Frederich RC, et al. Long-term weight loss maintenance; a meta-analysis of US studies. Am J Clin Nutr 74:579-584, 2001.

12) Oster G, Thompson D, Edelsberg J, et al. Lifetime health and economic benefits of weight loss among obese persons. Am J Public Health 89:1536-1542, 1999.

13) Watanabe S, Tsugane S, Sobue T, et al. Study design and organization of the JPHC Study. J Epidemiol 11:S3-S7, 2001.

14) Yamamoto S, Watanabe S. Geographic characteristics and mortality profiles in the JPHC Study. J Epidemiol 11:S8-S23, 2001.

15) Westenhoefer J, von Falk B, Stellfeldt A, et al. Behavioural correlates of successful weight reduction over 3 y. Results from the Lean Habits Study. Int J Obes Relat Metab Disord 28:334-335, 2004.

16) Kikuchi Y, Watanabe S. Personality and dietary habits. J Epidemiol 10:191-198, 2000.

17) Sasaki S, Yanagibori R, Amano K. Self reported diet history questionnaire developed for health education: a relative validation of the test version by comparison with 3-day diet record in women. J Epidemiol 8:203-215, 1998.

18) Yamada K, Morita A, Watanabe S. DNA polymorphism of obese people in Saku Control Obesity Program (SCOP). Anti-Aging Med 4:63-69, 2007.

19) Aiba N, Watanabe S, Morita A, et al. Nutritional education and exercise treatment based on cognitive behavioral treatment in the Saku Control Obesity Program (SCOP). Anti-Aging Med. (in press)

20) Morita S, Ohmori Y, Suzuki N, et al. Anthropometric and Clinical Findings in Obese Japanese: The Saku Control Obesity Program (SCOP). Anti-Aging Med. (in press)

21) Ministry of Health, Labour and Welfare. Mid-term evaluation report of Health Japan 21. Tokyo, 2006. (in Japanese)

22) Official Weight Watchers website. . http://www.weightwatchers.com /international. aspx

23) Wong CY. Byrne NM, O'Moore-Sullivan T, et al. Effect of Weight Loss Due to Lifestyle Intervention on Subclinical Cardiovascular Dysfunction in Obesity (Body Mass Index >30 kg/m2). Am J Cardiol 98:1593-1598, 2006.