In this study, we evaluated the link between a reduction of waist circumference and metabolic syndrome in obese Japanese subjects with a 1-year follow-up.

2. Subjects and methods

2.1. *Subjects*

We used data of 105 obese Japanese men (body mass index (BMI) ≧25 kg/m^2), aged 45.4 ± 8.4 years, retrospectively from a database of 14,345 subjects who met the following criteria: (1) received an annual health check-up at baseline from June 1997 to March 2006, (2) received an annual health check-up every year with a follow-up duration of 1 year, (3) received anthropometric measurements, fasting blood examination and blood pressure measurements as part of the annual health check-up, (4) received no medications for diabetes, hypertension, and/or dyslipidemia, and (5) provided written informed consent (Table 1).

At the first annual health check-up, all subjects were given instructions by well-trained medical staff on how to change their lifestyle.

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

2.2. *Anthropometric and body composition measurements*

The anthropometric and body compositions were evaluated based on the following parameters: height, body weight, waist circumference, hip circumference and body fat percentage. Body mass index (BMI) was calculated by weight/[height]^2 (kg/m^2) and obesity was defined by body mass index (BMI) ≧25 kg/m^2 [6]. The waist circumference was measured at the umbilical level, and the hip was measured at the widest circumferences over the trochanter in standing subjects after normal expiration. Body fat percentage was measured by an air displacement plethysmograph called the BOD POD Body Composition System (Life Measurement Instruments, Concord, CA, USA) [7,8].

2.3. *Blood pressure measurements at rest*

Resting systolic blood pressure and diastolic blood pressure were measured indirectly using a mercury sphygmomanometer placed on the right arm of the seated participant after at least 15 min of rest.

2.4. *Blood sampling and assays*

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

2.5. *Definition of metabolic syndrome*

Men with a waist circumference in excess of 85 cm were defined as having metabolic syndrome if they also had two or more of the following components: (1) dyslipidemia: triglycerides ≧150 mg/dl and/or HDL cholesterol <40 mg/dl, (2) high blood pressure: blood pressure ≧130/85 mmHg, (3) impaired glucose tolerance: fasting plasma glucose ≧110 mg/dl [9].

2.6. *Statistical analysis*

All data are expressed as mean ± standard deviation (S.D.) values. A statistical analysis was performed using a paired t test, an unpaired t test and χ^2 test: $p < 0.05$ was considered to be statistically significant.

3. Results

The clinical parameters at the baseline and the 1-year follow-up are summarized in Table 1. Anthropometric and body composition parameters such as body weight, body mass index, body fat percentage, waist circumference and hip circumference were significantly reduced after 1 year. Systolic blood pressure, diastolic blood pressure and triglyceride levels were also significantly reduced and HDL cholesterol significantly increased.

We investigated the changes in the number of subjects with metabolic syndrome as classified into different levels of

Table 1 – Clinical parameters at baseline and 1-year follow-up in obese Japanese men

	Mean ± S.D.		p
	Baseline	Follow-up	
Number of subjects	105		
Height (cm)	169.2 ± 5.2		
Body weight (kg)	80.9 ± 8.8	78.7 ± 8.9	<0.0001
Body mass index (kg/m^2)	28.2 ± 2.6	27.5 ± 2.7	<0.0001
Body fat percentage (%)	28.7 ± 4.8	26.9 ± 6	<0.0001
Waist circumference (cm)	93.3 ± 7.2	90.5 ± 8.1	<0.0001
Hip circumference (cm)	99.6 ± 4.5	98.3 ± 4.6	<0.0001
Systolic blood pressure (mmHg)	133.5 ± 15.4	124.3 ± 12.2	<0.0001
Diastolic blood pressure (mmHg)	83.0 ± 12.0	77.8 ± 9.5	<0.0001
Triglyceride (mg/dl)	167.2 ± 101.7	125.2 ± 70.4	<0.0001
HDL cholesterol (mg/dl)	51.0 ± 11.5	53.5 ± 13.6	0.0091
Blood sugar (mg/dl)	105.8 ± 21.3	106.1 ± 29.7	0.8773

Table 2 – Changes in the number of subjects with metabolic syndrome as classified into different levels of waist circumference and body weight reduction

		Number of subjects		Change rate (%)
		Baseline	Follow-up	
Delta waist circumference (cm)				
−1<		12	15	25.0
−2<	≦−1	8	4	−50.0
−3<	≦−2	6	3	−50.0
−4<	≦−3	5	2	−60.0
−5<	≦−4	5	1	−80.0
	≦−5	10	3	−70.0
Delta body weight (kg)				
−1<		15	13	−13.3
−2<	≦−1	8	5	−37.5
−3<	≦−2	6	2	−66.6
−4<	≦−3	7	3	−57.1
−5<	≦−4	3	4	33.3
	≦−5	7	1	−85.7

waist circumference and body weight reduction (Table 2). Change rate was under the level of −50% in subjects by at least 3 cm of waist circumference reduction. However, clear relation between body weight reduction and metabolic syndrome and the threshold of body weight reduction were not noted.

Forty-two men reduced their waist circumference by at least 3 cm by the time of the 1-year follow-up. We investigated the changes in the prevalence of metabolic syndrome amongst men who had different levels of waist circumference reduction [Group R: Delta (delta represents positive changes in parameters) waist circumference ≦−3 cm, Group C: Delta waist circumference > −3 cm] (Table 3). The prevalence of metabolic syndrome at baseline was 43.8% (Group R: 20 men, Group C: 26 men, total: 46 men). This was significantly reduced in both Group R (6 men, change rate: −70.0%) and total subjects (28 men, change rate: −39.1%) supporting the recommendation of the Japan society for the study of obesity. However, for Group C (22 men, change rate: −15.4%) the prevalence of metabolic syndrome was similar to baseline levels and the change rate was significantly lower compared with that in Group R.

Table 3 – Number of subjects with and without metabolic syndrome at baseline and follow-up

	Baseline	Follow-up		
		Group R	Group C	Total
Metabolic syndrome (+)	46	6	22	28
Metabolic syndrome (−)	59	36	41	77
p		0.0007	0.2558	0.0093

p: compared with baseline by χ^2 test. Group R: Delta waist circumference ≦−3 cm. Group C: Delta waist circumference > −3 cm.

We further analyzed changes in each component of metabolic syndrome at baseline and follow-up (Table 4). The prevalence of abdominal obesity diagnosed by waist circumference, hypertension and dyslipidemia was remarkably reduced in Group R and total subjects. Only the prevalence of hypertension was significantly reduced in Group C.

Finally, we compared the delta parameters between Group G and Group C (Table 5). Significant differences were noted in delta triglyceride and delta HDL cholesterol between Group R and Group C. However, delta systolic blood pressure, delta diastolic blood pressure and delta blood sugar in Group R were similar to those in Group C.

4. Discussion

We explored, using Japanese criterion, whether at least 3 cm of waist circumference reduction can improve metabolic syndrome in obese Japanese men.

In some literature, a reduction in waist circumferences is closely linked to an improvement of metabolic risk factors through life style modification [10,11]. Villareal et al. reported

Table 4 – Number of subjects with and without each component of metabolic syndrome at baseline and follow-up

	Baseline	Follow-up		
		Group R	Group C	Total
Abdominal obesity (+)	95	26	58	84
Abdominal obesity (−)	10	16	5	21
p		0.0001	0.7269	0.0324
Hypertension (+)	69	14	29	43
Hypertension (−)	36	28	34	62
p		0.0003	0.0122	0.0003
Dyslipidemia (+)	54	8	24	32
Dyslipidemia (−)	51	34	39	73
p		0.0003	0.0934	0.0020
Impaired glucose tolerance (+)	28	7	14	21
Impaired glucose tolerance (−)	77	35	49	84
p		0.1984	0.5195	0.2534

p: compared with baseline by χ^2 test. Group R: Delta waist circumference ≦−3 cm. Group C: Delta waist circumference > −3 cm. Abdominal obesity (+): waist circumference ≧85 cm.

Table 5 – Comparison of delta clinical parameters between group R and C

	Group R	Group C	p
Number of subjects	42	63	
Delta systolic blood pressure (mmHg)	−11.3 ± 14.7	−7.7 ± 11.2	0.1503
Delta diastolic blood pressure (mmHg)	−7.0 ± 11.6	−4.1 ± 11.6	0.2054
Delta triglyceride (mg/dl)	−76.3 ± 109.9	−19.1 ± 61.1	0.0009
Delta HDL cholesterol (mg/dl)	5.4 ± 11.7	0.6 ± 7.6	0.0127
Delta blood sugar (mg/dl)	−0.3 ± 24.4	0.7 ± 14.3	0.8099

Mean ± S.D. Group R: Delta waist circumference ≤ −3 cm. Group C: Delta waist circumference > −3 cm.

that in obese older adults after a 6-months trial, 10 cm of waist reduction through diet and exercise was associated with improvements in glucose (−4 mg/dl), systolic blood pressure (−10 mmHg), diastolic blood pressure (−8 mmHg), serum free fatty acids (−99 micromol/l) and the number of subjects with metabolic syndrome (59%) [10]. Kuller et al. also reported that 508 postmenopausal women through exercise and diet change could reduce their waist size by 10 cm. This also improved low-density lipoprotein cholesterol, insulin and glucose levels in an 18-months follow-up [11]. One common factor in both these interventions is a 10 cm waist circumference reduction.

In the present study, with a 1-year follow-up, approximately 3 cm of waist circumference reduction was noted and all the parameters of metabolic risk factors, except blood sugar, improved. The prevalence of metabolic syndrome was significantly reduced in Group R and total subjects, and we can conclude that at least 3 cm of waist reduction was beneficial for improving metabolic syndrome. However, the prevalence of metabolic syndrome did not change in Group C. In addition, although the prevalence of abdominal obesity which was diagnosed by waist circumference measurements, hypertension and dyslipidemia was significantly reduced in Group R, the prevalence of impaired glucose tolerance was similar at the follow-up as it was at the baseline. Finally, the differences of delta parameters were noted only in delta triglyceride and delta HDL cholesterol. In sum, the main clinical impact of dyslipidemia was noted in the obese Japanese men with at least 3 cm of waist circumference reduction. Tonstand et al. [12] also reported that a difference of 3.1 cm of waist circumference was noted between an intervention group with nurse-led lifestyle counseling and a control group. Although there was a difference in triglyceride between the two groups, the difference in blood pressure was not at a significant level. These results suggest that an improvement of metabolic risk factors may be different according to the level of waist circumference reduction.

There are several potential limits in this study. First, although we proved a link between a reduction in waist circumference and metabolic risk factors, and it seems that at least 3 cm of waist circumference reduction was beneficial for improving metabolic syndrome, we could not prove the precise threshold of waist circumference reduction as well as body weight reduction. Second, we could not directly measure visceral fat accumulation using computed tomography. Finally, the small number of subjects is a limitation of this study.

In conclusion, it may be beneficial for obese Japanese men to reduce their waist circumference by at least 3 cm for improving metabolic syndrome.

Conflict of interest statement

All co-authors have no conflict of interest..

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Original Article

Linkage between Oxygen Uptake at Ventilatory Threshold and Muscle Strength in Subjects with and without Metabolic Syndrome

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We evaluated the linkage between oxygen uptake at the ventilatory threshold (VT) and muscle strength in subjects with and without metabolic syndrome. We used data of 226 Japanese men with metabolic syndrome and 265 Japanese men without the syndrome. Metabolic syndrome has recently been defined by a new criterion in Japan. Oxygen uptake at VT and muscle strength, *i.e.* grip strength and leg strength were measured. Oxygen uptake at VT and muscle strength/body weight were found to be significantly lower in subjects with metabolic syndrome than in those without the syndrome. However, the differences did not reach significant levels after adjusting for leg strength/body weight or oxygen uptake at VT. A combination of aerobic exercise and resistance training might be considered for preventing and improving metabolic syndrome.

Key words: metabolic syndrome, oxygen uptake, ventilatory threshold, muscle strength

Metabolic syndrome is a common disorder and has become a public health challenge in Japan [1, 2]. Lifestyle modifications, especially exercise, are important for preventing and improving metabolic syndrome. We have previously reported that a lower level of oxygen uptake at VT (ventilatory threshold) [3], which is the upper limit of aerobic exercise and is thought to serve as an accurate and reliable standard for exercise prescription [3], and lower muscle strength/body weight [4] were characteristic in subjects with metabolic syndrome. However, the relation between oxygen uptake at VT and muscle strength in subjects with and without metabolic syndrome remains to be investigated. In this study, we compared both oxygen uptake at VT and muscle strength in Japanese men with and without metabolic syndrome. In addition, the linkage between oxygen uptake at VT and muscle strength was also examined.

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Subjects and Methods

Subjects. We used retrospective data of 226 Japanese men with metabolic syndrome and 265 Japanese men without metabolic syndrome, aged 21-

77 years from a data base of 14,345 subjects. All subjects met the following criteria: (1) they had received an annual health checkup from June 1997 to May 2006 at Okayama Southern Institute of Health; (2) they had received a fasting blood examination, a cardiopulmonary exercise test and muscle strength measurements as part of their annual health checkups; and (3) they provided informed consent. Ethical approval for the study was obtained from the Ethical Committee of Okayama Health Foundation.

Oxygen uptake at VT. A graded ergometer exercise protocol [5] had been carried out at the subjects' checkups. After breakfast (2 h), resting ECG was recorded and blood pressure was measured. All subjects were then given a 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 [5], in which the workloads reach the predicted $\dot{V}O_2max$ 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. 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 the cardiopulmonary gas exchange system (Oxycon Alpha, Mijnhrdt b.v., Netherlands). The ventilatory threshold (VT) was determined by the standard of Wasserman *et al.* [6], Davis *et al.* [7] and the V-slope method of Beaver [8] from $\dot{V}O_2$, $\dot{V}CO_2$, and minute ventilation ($\dot{V}E$).

Measurements of muscle strength. To assess muscle strength, grip and leg strength had been measured. Grip strength was measured 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. Next, the subject extended the leg to 60 degrees [9]. To standardize the influence of the total body weight, we calculated the muscle strength (kg) per body weight (kg) [10].

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. Metabolic syndrome was defined, among men with a waist circumference in excess of 85 cm, as the appearance of 2 or more of the following symptoms: 1) dyslipidemia: triglycerides $\geqq$ 150 mg/dl and/or HDL cholesterol < 40 mg/dl, 2) high blood pressure: blood pressure $\geqq$ 130/85 mmHg, and 3) impaired glucose tolerance: fasting plasma glucose $\geqq$ 110 mg/dl [1].

Statistical analysis. Data are expressed as means ± standard deviation (SD) values. A comparison of parameters between the 2 groups was made using the unpaired *t*-test and covariance analysis. Simple correlation analysis was performed as well to test for the significance of the linear relationship among continuous variables: $p < 0.05$ was considered to be statistically significant.

Results

The measurements of oxygen uptake at VT and muscle strength in subjects with and without metabolic syndrome are indicated in the Table 1. There was no significant difference in age between subjects with and without the syndrome. Body weight and waist circumference in subjects with metabolic syndrome were higher than those in subjects without the syndrome. In subjects with metabolic syndrome, oxygen uptake at VT, grip strength/body weight and leg strength/body weight (WBI: weight bearing index) were significantly lower than those without the syndrome. Leg strength in subjects with metabolic syndrome was significantly higher than that without the syndrome.

To avoid the influence of muscle strength on oxygen uptake at VT, we used WBI as a covariate and compared oxygen uptake at VT using covariance analysis. In subjects with metabolic syndrome, oxygen uptake at VT showed comparable levels to that of subjects without the syndrome. The differences in oxygen uptake at VT between men with and without metabolic syndrome did not show statistical significance after adjusting for other parameters of muscle strength *i.e.* grip strength, leg strength and muscle strength/body weight. In turn, to eliminate the influence of oxygen uptake at VT on muscle strength, we used oxygen uptake at VT as a covariate and compared muscle strength. After adjusting for oxygen uptake at VT, no significant difference in leg strength and muscle strength/body weight was observed between Japanese men with and without metabolic syndrome.

We investigated the relationship between oxygen uptake at VT and the parameters of muscle strength and muscle strength/body weight. Oxygen uptake at VT was weakly correlated with muscle strength and muscle strength/body weight parameters in metabolic syndrome, non-metabolic syndrome and all subjects (Table 2).

Discussion

We investigated the linkage between oxygen uptake at VT and muscle strength in metabolic syndrome.

In some of the literature, cardiorespiratory fitness and muscle strength are closely associated with metabolic syndrome [11–14]. There are few studies focusing on the reciprocal effect of oxygen uptake at VT and muscle strength on metabolic syndrome. Jurca R *et al.* have reported examining the associations for muscle strength with the prevalence of metabolic syndrome using the National Cholesterol Education Program definition [14]. They concluded that muscle strength has an inverse association with metabolic syndrome, but the association was attenuated when further adjusted for cardiorespiratory fitness. In this study, using the new Japanese criteria for metabolic syn-

Table 1 Comparison of parameters between Japanese men with and without metabolic syndrome

	Metabolic syndrome (+)	Metabolic syndrome (−)	*p*	*p*	*p*
Number of subjects	226	265	Unpaired t test	Adjusting for WBI	Adjusting for VT
Age	49.1 ± 10.5	49.3 ± 11.1	0.8428		
Height (cm)	168.6 ± 5.8	168.3 ± 5.7	0.5756		
Body weight (kg)	81.2 ± 12.8	71.9 ± 12.1	< 0.0001		
Waist circumference (cm)	95.6 ± 8.4	85.9 ± 9.2	< 0.0001		
Oxygen uptake at VT (ml/kg/min)	13.2 ± 2.2	14.8 ± 3.4	< 0.0001	0.0611	
Right grip strength (kg)	44.5 ± 8.3	43.5 ± 8.6	0.1792		0.5528
Left grip strength (kg)	42.6 ± 7.9	42.0 ± 8.0	0.4282		0.5790
Leg strength (kg)	68.2 ± 18.1	64.9 ± 17.5	0.0405		0.7202
Right grip strength (kg)/body weight (kg)	0.55 ± 0.10	0.61 ± 0.11	< 0.0001		0.1377
Left grip strength (kg)/body weight (kg)	0.53 ± 0.10	0.59 ± 0.10	< 0.0001		0.1381
WBI	0.84 ± 0.20	0.90 ± 0.20	0.0008		0.9420

VT: Ventilatory threshold
WBI: Weight bearing index [leg strength (kg)/body weight (kg)]

Table 2 Simple correlation analysis between oxygen uptake at VT and muscle strength parameters

	Total		Metabolic syndrome (+)		Metabolic syndrome (−)	
	r	*p*	r	*p*	r	*p*
Right grip strength (kg)	0.160	0.0004	0.199	0.0026	0.180	0.0033
Left grip strength (kg)	0.152	0.0007	0.175	0.0082	0.170	0.0055
Leg strength (kg)	0.145	0.0013	0.140	0.0350	0.204	0.0008
Right grip strength (kg)/body weight (kg)	0.365	< 0.0001	0.281	< 0.0001	0.345	< 0.0001
Left grip strength (kg)/body weight (kg)	0.350	< 0.0001	0.248	0.0002	0.330	< 0.0001
WBI	0.336	< 0.0001	0.212	0.0013	0.371	< 0.0001

VT: Ventilatory threshold
WBI: Weight bearing index [leg strength (kg)/body weight (kg)]

drome, leg strength was found to be significantly higher in subjects with than in those without the syndrome. Oxygen uptake at VT and muscle strength/body weight were significantly lower in subjects with metabolic syndrome than in those without it. However, the differences weren't significant when adjusted for WBI or oxygen uptake at VT.

Kawano H *et al.* evaluated the effects of moderate resistance training as well as combined resistance and aerobic training intervention on carotid arterial compliance. They concluded that aerobic training could prevent the stiffening of carotid arteries caused by resistance training [15]. Sandvik L *et al.* reported that physical fitness was a graded, independent, long-term predictor of mortality from cardiovascular causes in healthy, middle-aged men [16]. Metter EJ *et al.* also reported that lower and declining muscle strength was associated with increased mortality, independent of physical activity and muscle mass [17]. These findings suggest that a combination of aerobic exercise and resistance training should be considered for primary prevention of metabolic syndrome. In this study, we found lower levels of oxygen uptake at VT and lower muscle strength/body weight in subjects with metabolic syndrome, as previously reported [3, 4]. However, the differences were not significant after adjusting for muscle strength parameters and oxygen uptake at VT. In addition, oxygen uptake at VT was weakly correlated with muscle strength and muscle strength/body weight parameters. Therefore, oxygen uptake at VT and muscle strength partially depend on each other in subjects with and without the syndrome. Especially in subjects with metabolic syndrome, lower WBI was also noted. A low level of WBI and reduced exercise activity seems to accelerate metabolic syndrome. Although aerobic exercise has traditionally been advocated as the most suitable for reducing fat mass [18, 19], it is difficult for subjects with metabolic syndrome to support the entire body's weight; it is also difficult for subjects with metabolic syndrome to carry out aerobic exercise *i.e.* walking and jogging. A combination of aerobic exercise and resistance training might be considered for preventing and improving metabolic syndrome. It is important for metabolic syndrome patients to maintain or maximize the muscle strength of their lower limbs as well as to carry out aerobic exercise.

Potential limitations remain in our study. First, the cross-sectional study design as well as the small sample size in our study makes it difficult to infer causality between metabolic syndrome, oxygen uptake at VT and muscle strength. Second, we could not accurately prove the mechanism of linkage between oxygen uptake at VT and muscle strength.

In conclusion, both aerobic exercise and resistance training are necessary for the prevention and treatment of metabolic syndrome.

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Short Communication

Re-evaluation of Waist Circumference in Metabolic Syndrome: A Comparison between Japanese Men and Women

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We re-evaluated the criteria for waist circumference to predict the accumulation of the components of metabolic syndrome. We used data for 3,185 Japanese, aged 20-79 years. Metabolic syndrome has recently been redefined by a new criterion in Japan, in which waist circumference cutoff points, *i.e.* 85 cm for men and 90 cm for women, are employed. Among the 3,185 Japanese considered in the present study, 335 men (26.8%) and 69 women (3.6%) were diagnosed as having metabolic syndrome. A cutoff point as a predictor for 2 or more components of metabolic syndrome was evaluated by sensitivity/specificity and a receiver operating characteristic (ROC) curve. The optimal point was estimated as being approximately 85 cm of waist circumference in men and 75 cm in women. We therefore recommend a cutoff value, 75 cm of waist circumference, for the criterion of metabolic syndrome in women.

Key words: metabolic syndrome, waist circumference, sensitivity, specificity, receiver operating characteristic (ROC) curve

Metabolic syndrome is now one of the major targets of the current public health challenge. Since the work of Reaven [1], the syndrome has been well-documented to be associated with an increased risk of cardiovascular disease and is correlated with all-cause mortality [2]. At present, the internationally recognized definitions of metabolic syndrome have been released, namely the criteria of the World health Organization [3], the National Cholesterol Education Program's Third Adult Treatment Panel Report (ATPIII) [4], and the International Diabetes Federation (IDF) [5]. A new criterion for metabolic syndrome has recently been defined in Japan [6], and we have previously reported that 30.7% of men and 3.6% of women can be diagnosed as having metabolic syndrome, with the prevalence being 10-fold higher in men than in women based on use of the new criterion [7]. This difference between men and women was due to the prevalence of women with a waist circumference in excess of 90 cm being significantly lower than that of men with a waist circumference exceeding 85 cm. The cutoff point of waist circumference corresponds to 100 cm^2 of the visceral adipose area measured by computed tomography at the umbilical level. The aim of this study was to re-evaluate the waist circumference for detecting metabolic risk accumulation in Okayama prefecture, Japan.

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Subjects and Methods

We used data for 3,185 Japanese (1,252 men and 1,933 women) aged 20–79 years, who received annual health check-ups at Okayama Southern Institute of Health with informed consent. We measured waist circumference at the umbilical level. Metabolic syndrome was defined among men and women as waist circumferences in excess of 85 cm and 90 cm [6], respectively, in addition to having 2 or more of the following components: 1) Dyslipidemia: triglycerides ≧ 150 mg/dl and/or HDL cholesterol < 40 mg/dl; 2) High blood pressure: blood pressure ≧ 130/85 mmHg; 3) Impaired fasting glucose: fasting plasma glucose ≧ 110 mg/dl [6].

Results

The mean age of the study subjects was 46.7 ± 12.3 years for men and 48.5 ± 12.6 years for women. Among the 3,185 Japanese subjects, 618 men (49.4%) had a waist circumference in excess of 85 cm and 126 women (6.5%) had a waist circumference exceeding 90 cm. In addition, the prevalence of metabolic syndrome was found to gradually increased with age, and 335 men (26.8%) were diagnosed with having metabolic syndrome in men. The prevalence of metabolic syndrome also gradually increased with age in women, especially over the age of 50, though only 69 women (3.6%) were diagnosed with metabolic syndrome.

We investigated the sensitivity and specificity of waist circumference in predicting the association with 2 or more metabolic risk factors, *i.e.* dyslipidemia, high blood pressure, and impaired fasting glucose. In men, the sensitivity and specificity of the waist circumference criterion, *i.e.* 85 cm, were 66.3 % and 62.1%, respectively. However, in women, the sensitivity and specificity of waist circumference criterion, 90 cm, were found to be 16.0% and 96.2%. A cutoff point as a predictor for 2 or more components of metabolic syndrome was evaluated by sensitivity/specificity curves as well as a receiver operating characteristic (ROC) curve. The optimal point yielding the maximal sensitivity plus specificity for predicting 2 or more risk factors was estimated to be

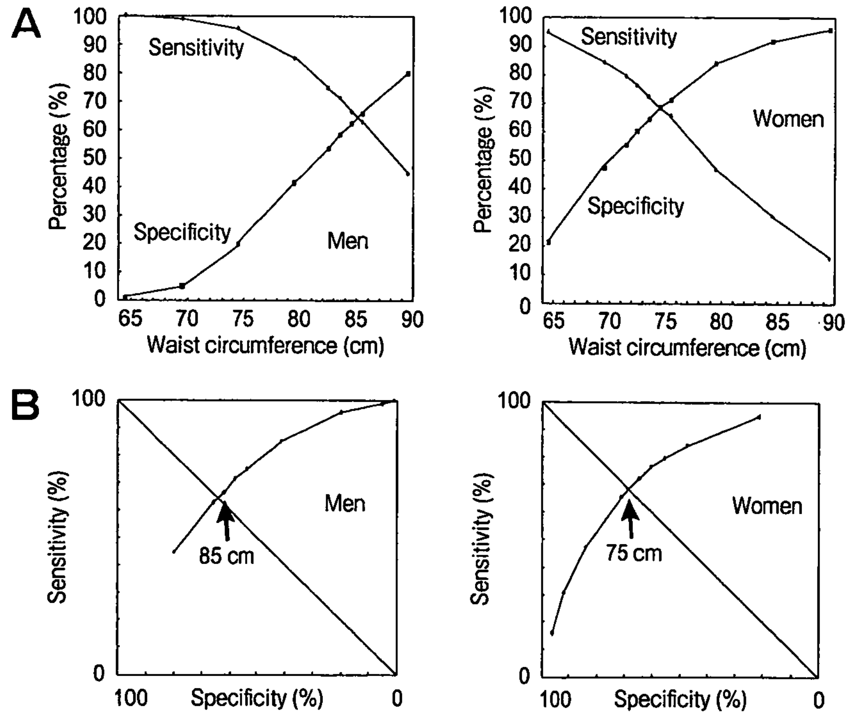

Fig. 1 A, Sensitivity/specificity curve of waist circumference for detecting metabolic risk factor accumulation; B, Receiver operating characteristic (ROC) curve of waist circumference for detecting metabolic risk factor accumulation.

approximately 85 cm (sensitivity: 66.3%, specificity: 62.1%) of waist circumference in men and 75 cm (sensitivity: 68.2%, specificity: 68.7%) in women (Fig. 1). Consequently, 764 women (39.5%) had a waist circumference exceeding 75 cm and 294 women (15.2%) were diagnosed as having metabolic syndrome by using 75 cm as the waist circumference criterion.

Discussion

The primary finding of this study was that a waist circumference of 75 cm in women is appropriate for predicting the clustering of the components of metabolic syndrome. In men, the criterion of waist circumference deduced from our study was exactly matched to that of the new criterion in Japan. In women, however, the cutoff of waist circumference in our study was lower than that of the new criterion in Japan. Hara K and Kadowaki T *et al.* have also reported that waist circumference of 85 cm in men and 78 cm in women are cutoff points yielding the maximal sensitivity plus specificity for predicting the presence of multiple risk factors [8]. Miyazaki T and Nakao K *et al.* have reported that, by using the computed tomography, visceral fat accumulation of 65 cm^2 is optimal for evaluating multiple risk factors, and the corresponding cutoff value for waist circumference is 77 cm in women [9]. Although we did not measure visceral fat accumulation by computed tomography, the prevalence ratio of metabolic syndrome (men/women) based on use of a waist circumference of 75 cm in women was similar to that of cardiovascular diseases in Japan (Ministry of Health, Labor and Welfare, Japan. Available from wwwdbtk.mhlw.go.jp/toukei/kouhyo/data-kou18/data12/junkan-h12-2.pdf accessed Apr 15, 2006, in Japanese).

Potential limitations remain in our study. The cross-sectional study design of our study makes it difficult to infer causality between waist circumference and metabolic risk factors. The enrolled subjects in our study voluntarily received the annual health check-ups; they were therefore more health-conscious than average, which may have caused some bias in the current study. In addition, McNeil AM *et al.* assessed the association between metabolic syndrome using the ATPIII definition and cardiovasucular disease with an 11-year follow-up period, and they reported that waist circumference is not a significant predictor for cardiovascular disease [10]. Therefore, our findings are not fully applicable to clinical and public health practice settings. In conclusion, although follow-up studies are required to prove the feasibility of the definition of metabolic syndrome to predict the development of cardiovascular disease, we would recommend a cutoff value of 75 cm of waist circumference as a criterion for metabolic syndrome in women.

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Short Communication

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

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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

Metabolic 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. Anthropom etric parameters *i.e.* height, weight, and waist circumference were measured. The waist circumference was measured at the umbilical level.

Definition of metabolic syndrome. Meta-

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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 ≧ 150 mg/dl and/or HDL cholesterol < 40 mg/dl, 2) High blood pressure: blood pressure ≧ 130/85 mmHg, 3) Impaired glucose tolerance: fasting plasma glucose ≧ 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 without 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.

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Comparison of Whole Body Reaction Time between Japanese Men with and without Metabolic Syndrome

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We investigated the relation between metabolic syndrome and whole body reaction time. We used data for 169 men with metabolic syndrome and 398 men without. Metabolic syndrome was defined by a new criteria developed in Japan. Whole body reaction time was also measured by THP-15 (Sakai, Tokyo, Japan). Whole body reaction time in men with metabolic syndrome was significantly longer than without the syndrome. In addition, the clinical impact of dyslipidemia and body mass index (BMI) was also noted. Longer whole body reaction time was noted in Japanese men with metabolic syndrome.

Keywords: Whole body reaction time, Metabolic syndrome, Dyslipidemia

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1. Introduction

We have reported that lower oxygen uptake at ventilatory threshold (Miyatake, et al., 2007) and lower muscle strength per body weight (Miyatake, et al., 2007) were characteristic in subjects with metabolic syndrome. For preventing life-style related diseases, the level of maximal oxygen uptake and muscle strength was recommended in the Exercise and Physical Activity Reference Quantity for Health Promotion 2006 (EPARQ2006) by the Ministry of Health, Labor and Welfare of Japan. However, in relation to other types of physical fitness *i.e.* agility, there are no studies that focused on reductions in mortality or the prevention of lifestyle-related diseases, and an optimal level has not been defined. In addition, although it is reported that neuropathy which may affect agility is caused by type 2 diabetes mellitus and hyper triglyceridemia, the relation between metabolic syndrome and agility still remains to be investigated.

In this study, to investigate the relation between metabolic syndrome and agility using the criteria developed in Japan, we measured whole body reaction time which is one of the common parameters of agility in subjects with metabolic syndrome and compared it with those without the syndrome.

2. Methods

We used data for 169 men (49.9±10.6 years) with metabolic syndrome and 398 men (48.6±12.4 years) without the syndrome with written informed consent.

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). Waist circumference was measured at the umbilical level.

Metabolic 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≧150 mg/dl and/or HDL cholesterol<40 mg/dl, 2) High blood pressure: blood pressure≧130/85 mmHg, 3) Impaired glucose tolerance: fasting plasma glucose≧110 mg/dl (2005).

Whole body reaction time was measured by using THP-15 (Sakai, Tokyo, Japan) (**Figure 1**) as follows. Subjects stood still with a posture to be able to change immediately and concentrated their attention on a lamp. When the lamp was lit, the subjects jumped as quickly as possible. The average reaction

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

	Metabolic syndrome (+)	Metabolic syndrome (−)	*p* Unpaired t test	*p* Adjusting for age	*p* Adjusting for BMI	*p* Adjusting for age and BMI
Number of subjects	169	398				
Age	49.9 ± 10.6	48.6 ± 12.4	0.2262			
Height (cm)	168.8 ± 6.0	167.9 ± 6.1	0.1060			
Body weight (kg)	79.1 ± 13.5	66.5 ± 9.7	<0.0001			
Body mass index (kg/m^2)	27.7 ± 4.0	23.5 ± 2.9	<0.0001			
Whole body reaction time (sec)	0.400 ± 0.072	0.390 ± 0.076		0.0022	0.0498	0.1267
	Waist circumference (+)	Waist circumference (−)				
Number of subjects	274	293				
Age	48.9 ± 11.0	49.0 ± 12.6	0.9200			
Whole body reaction time (sec)	0.398 ± 0.077	0.388 ± 0.072		0.1014	0.1966	0.0816
	Impaired glucose tolerance (+)	Impaired glucose tolerance (−)				
Number of subjects	155	412				
Age	53.2 ± 10.1	47.4 ± 12.1	<0.0001			
Whole body reaction time (sec)	0.413 ± 0.083	0.385 ± 0.070		0.7112	0.8371	0.4658
	Dyslipidemia (+)	Dyslipidemia (−)				
Number of subjects	284	283				
Age	48.8 ± 11.1	49.2 ± 12.6	0.7239			
Whole body reaction time (sec)	0.396 ± 0.071	0.390 ± 0.078		0.0032	0.2653	0.1691
	High blood pressure (+)	High blood pressure (−)				
Number of subjects	344	223				
Age	50.4 ± 11.5	46.8 ± 12.1	0.0003			
Whole body reaction time (sec)	0.397 ± 0.077	0.386 ± 0.071		0.7563	0.2893	0.0801

Mean ± SD
BMI: body mass index

Figure 1 Measurement of whole body reaction time photographed at Okayama Southern Institute of Health, Okayama, Japan

time of five times that both legs completely left the floor was employed to be whole body reaction time.

Data were expressed as mean ± standard deviation. Unpaired *t* test and covariance analysis were performed; $p<0.05$ was statistically significant.

3. Results

Whole body reaction time in subjects with metabolic syndrome (0.400±0.072 sec) was significantly longer than those without the syndrome (0.390±0.076 sec) after adjusting for age ($p=0.0022$) and BMI ($p=0.0498$) by covariance analysis (**Table 1**). However, after adjusting for both age and BMI, whole body reaction time in subjects with metabolic syndrome was similar to those without the syndrome.

We then analyzed the groups with and without each component of metabolic syndrome *i.e.* waist circumference, dyslipidemia, high blood pressure and impaired glucose tolerance (**Table 1**). Based on the comparison of whole body reaction time adjusting for age, in subjects with dyslipidemia (n=284), whole body reaction time was significantly longer (0.396±0.071 sec) than those without dyslipidemia (n=283) (0.390±0.078 sec) ($p=0.0032$). In turn, after adjusting for BMI or after adjusting for both age and BMI, the difference of whole body reaction time between men with and without dyslipidemia was not at a significant level. In addition, there was no significant difference between men with and without each component, *i.e.* abdominal obesity, high blood pressure and impaired glucose tolerance after adjusting for age, BMI, and both age and BMI.

4. Discussion

This is the first report of the relation between whole body reaction time and metabolic syndrome using criteria in Japan and longer whole body reaction time was noted in subjects with the syndrome. Drory, et al., (1999) reported that they evaluated subjects with hyper triglyceridemia without other causes of neuropathy and found mild signs of an asymptomatic motor and/or sensory and/or autonomic axonal polyneuropathy. Kassem, et al., (2005) also reported that hypertriglyceridemia is associated with early peripheral neuropathy. In addition, we previously reported on lower leg strength per body weight and higher BMI in men with metabolic syndrome than in those without the syndrome. In this study, longer whole body reaction time was observed in subjects with metabolic syndrome and clinical significance of dyslipidemia and BMI on whole body reaction time in subjects with metabolic syndrome was also noted. Neuropathy caused by dyslipidemia and lower leg strength per body weight may be one of the possible mechanisms. Kassem, et al., (2005) investigated the correlation between hypertriglyceridemia and peripheral neuropathy by using an electroneurographic study. They reported that abnormalities in longer nerves of the lower extremities were observed and alterations of myelin sheaths in the sural nerve might affect parameters.

Potential limitations still remain in this study. First, our study was cross sectional, not longitudinal. Second, we could not accurately prove the mechanism of the relationship between whole body reaction time and metabolic syndrome. Third, although increased reaction time was reported in subjects with type 2 diabetes (Richerson, et al., 2005), we could not find the difference of whole body reaction time between men with and without impaired glucose tolerance. The difference between the definition of impaired glucose tolerance in metabolic syndrome (fasting plasma glucose≧110 mg/dl) and that of type 2 diabetes mellitus (fasting plasma glucose≧126 mg/dl) may affect the results. In conclusion, longer whole body reaction time was noted in Japanese men with metabolic syndrome. Further studies are needed to prove the clinical significance of longer whole body reaction time on metabolic syndrome.

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臨スポオピニオン

健康づくりのための運動基準と健康運動指導士などの専門家としての役割について

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はじめに

平成20年4月から，40〜74歳の医療保険加入者(被扶養者を含む)を対象に，糖尿病など生活習慣病の有病者などの減少を目的としたメタボリックシンドローム(内臓脂肪症候群)の概念を導入した特定健康診査・特定保健指導を実施することが法律で義務づけられる．その背景には日本の医療費が年々肥大化を続け，平成17年度の国民医療費がついに33兆円となったことである．その内訳をみると，生活習慣病に関係するものが約1/3を占めているので，生活習慣病をいかに予防するかが，大きな課題となっていることがわかる．メタボリックシンドローム該当者やその予備軍を早期に発見し，適切な治療と生活習慣の改善に向けた指導を行うことにより，生活習慣病の発症や重症化を防ぎ，その結果，中長期的に医療費の増加を抑えることになる．

最近では，国民の2/3が運動習慣を身につけていない状態で生活習慣病が問題となっているため，生活習慣病対策においては，厚生労働省の掲げる健康増進月間の「1に運動，2に食事，しっかり禁煙，最後にクスリ」の標語の下，身体活動・運動がより一層注目されている．そこで，平成18年7月に厚生労働省から健康づくりのための運動基準2006－体活動・運動・体力－(以下，運動基準)と健康づくりのための運動指針2006(エクササイズガイド2006)(以下，エクササイズガイド)が発表された．

運動基準とエクササイズガイド2006とは

運動基準では，メッツ・時/週(エクササイズ)とは，週当たりの身体活動・運動量であり，運動強度の指標であるメッツ(MET：安静時のエネルギー代謝量(酸素摂取量換算で体重当たり3.5ml/kg/分)の倍数)に活動時間を掛けたものである．目標としては“週に23エクササイズ”以上の活発な身体活動(運動・生活活動)を行い，そのうち4エクササイズ“以上の活発な運動を行うこと”である．今回の運動基準では，身体活動と運動を区別して基準値を定めた．身体運動と運動を，“身体活動とは，骨格筋の収縮を伴い安静時よりも多くのエネルギー消費を伴う身体の状態である．それは，日常生活における労働，家事，通勤・通学，趣味などの「生活活動」と，体力の維持・向上を目的として計画的・意図的に実施する「運動」の2つに分けられる”と定義している(図-1)．また，メタボリックシンドローム解消に必要な運動量は10エクササイズの運動量が必要であるとしている．メタボリックシンドローム解消のためには体重の減少が必要だが，正味のエネルギー消費量のみが有効であるという理由から運動による正味のエネルギー消費量を表-1に示した．

運動基準とエクササイズガイド2006の効果

1. 運動基準とエクササイズガイド2006は非常にわかりやすく，消費カロリー計算も簡単なので普及しやすい．

2. スポーツを含む運動よりも，生活の中にこまめに身体活動を増やすことを勧めているので特別な機材や場所を必要としない．

3. 特定健康診査・特定保健指導の対象になっているメタボリックシンドロームの解消に必要な運動量は10エクササイズが必要であると示してい

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