Table 4. Comparison of coffee, tea and green tea consumption between subjects with and without metabolic components.

	Meabolic syndrome (–)	Metabolic syndrome (+)	p	p (After adjusting for age)	p
Men					
Number of subjects	116	34			
Age	46.0 ± 13.0	48.9 ± 9.8	0.2279		
Coffee consumption (cup/week)	9.6 ± 9.1	12.0 ± 8.7	0.1756	0.9010	0.6155*
Tea consumption (cup/week)	1.7 ± 4.5	0.8 ± 2.0	0.2478	0.3793	0.2520**
Green tea consumption (cup/week)	6.8 ± 6.9	4.5 ± 5.4	0.0783	0.8514	**0.0072*****
Women					
Number of subjects	217	10			
Age	42.8 ± 14.7	59.3 ± 9.5	**0.0005**		
Coffee consumption (cup/week)	8.7 ± 9.1	6.1 ± 5.0	0.3670	0.4577	**0.0312***
Tea consumption (cup/week)	2.2 ± 3.0	1.3 ± 2.1	0.3649	0.8545	0.3780**
Green tea consumption (cup/week)	7.5 ± 8.7	4.9 ± 4.6	0.3432	0.9777	**0.0208*****

*: After adjusting for age, exercise habits, smoking habits, tea consumption and greeen tea consumption; **: After adjusting for age, exercise habits, smoking habits, coffee consumption and green tea consumption; ***: After adjusting for age, exercise habits, smoking habits, coffee consumption and tea consumption.

coffee, tea and green tea consumption. Some studies have showed that habitual coffee consumption may improve insulin resistance and abdominal glucose metabolism [9-11]. However, we evaluated simplistic scientific and speculative approach to study these subjects without any laboratory measurements *i.e.* adipokines and insulin resistance. In addition, small sample size (low statistical power) in subjects with metabolic syndrome, especially women, and possibility of misclassification relying only on purported consumption made it difficult to prove the link. Fourth, for, example, the coffee consumption was reported to be 10.6 cups/week/person in 2008, and it is the highest between 40 and 59 (men: 13.5 cups/week/person, women: 14.2 cups/week/person) in Japanese by All Japan Coffee Association [7]. The coffee consumption was gradually increasing [7]. In this study, the mean of the coffee consumption was lower than that in the previous report. Further prospective studies are needed in Japanese subjects in Japanese.

REFERENCES

[1] Japanese Society of Internal Medicine (2005) Definition and the diagnostic standard for metabolic syndrome-Committee to evaluate diagnostic standards for metabolic syndrome. *Nippon Naika Gakkai Zasshi*, **94**, 794-809. doi:10.2169/naika.94.794

[2] Miyatake, N., Kawasaki, Y., Nishikawa, H., Takenami, S. and Numata, T. (2006) Prevalence of metabolic syndrome in Okayama prefecture. *Internal Medicine*, **45**, 107-108. doi:10.2169/internalmedicine.45.1509

[3] Wilson, P.W., Kannel, W.B., Silbershatz, H. and D'Agostino, R.B. (1999) Clustering of metabolic factors and coronary heart disease. *Archives of Internal Medicine*, **159**, 1104-1109. doi:10.1001/archinte.159.10.1104

[4] Miyatake, N., Wada, J., Kawasaki, Y., Matsumoto, S., Makino, H. and Numata, T. (2006) Relationship between metabolic syndrome and proteinuria in the Japanese population. *Internal Medicine*, **45**, 599-603. doi:10.2169/internalmedicine.45.1681

[5] Miyatake, N., Matsumoto, S., Makino, H. and Numata, T. (2007) Comparison of hepatic enzymes between Japanese men with and without metabolic syndrome. *Acta Medica Okayama*, **61**, 31-34.

[6] Numata, T., Miyatake, N., Wada, J. and Makino, H. (2008) Comparison of serum uric acid levels between Japanese with and without metabolic syndrome. *Diabetes Research and Clinical Practice*, **80**, 1-5. doi:10.1016/j.diabres.2007.10.031

[7] http://coffee.ajca.or.jp/wp-content/uploads/2011/09/data04_2011-04.pdf (in Japanese).

[8] Iso, H., Date, C., Wakai, K., Fukui, M. and Tamakoshi, A. (2006) The relationship between green tea and total caffeine intake and risk for self-reported type 2 diabetes among Japanese adults. *Annals of Internal Medicine*, **144**, 554-562.

[9] Tunnicliffe, J.M. and Shearer, J. (2008) Coffee, glucose homeostasis, and insulin resistance: physiological mechanisms and mediators. *Applied Physiology, Nutrition and Metabolism*, **33**, 1290-1300. doi:10.1139/H08-123

[10] Van Dam, R.M. (2008) Coffee consumption and risk of type 2 diabetes, cardiovascular diseases, and cancer. *Applied Physiology, Nutrition and Metabolism*, **33**, 1269-1283. doi:10.1139/H08-120

[11] Greenberg, J.A., Boozer, C.N. and Geliebter, A. (2006) Coffee, diabetes, and weight control. *American Journal of Clinical Nutrition*, **84**, 682-693.

[12] Yuji, M. (2002) New criteria for "obesity disease" in Japan: The examination committee of criteria for "obesity disease" in Japan, Japan society for the study of obesity. *Circulation Journal*, **66**, 987-992.

[13] Hino, A., Adachi, H., Enomoto, M., Furuki, K., Shigetoh,

Y., Ohtsuka, M., Kumagae, S., Hirai, Y., Jalaldin, A., Satoh, A. and Imaizumi, T. (2007) Habitual coffee but not green tea consumption is inversely associated with metabolic syndrome: An epidemiological study in a general Japanese population. *Diabetes Research and Clinical Practice*, **76**, 383-389. doi:10.1016/j.diabres.2006.09.033

[14] Balk, L., Hoekstra, T. and Twisk, J. (2009) Relationship between long-term coffee consumption and components of the metabolic syndrome: The Amsterdam Growth and Health Longitudinal Study. *European Journal of Epidemiology*, **24**, 203-209. doi:10.1007/s10654-009-9323-1

[15] Driessen, M.T., Koppes, L.L., Veldhuis, L., Samoocha, D. and Twisk, J.W. (2009) Coffee consumption is not related to the metabolic syndrome at the age of 36 years: The Amsterdam Growth and Health Longitudinal Study. *European Journal of Clinical Nutrition*, **63**, 536-542. doi:10.1038/ejcn.2008.6

Open Journal of Epidemiology, 2012, 2, 50-54 **OJEpi**
doi:10.4236/ojepi.2012.22008 Published Online May 2012 (http://www.SciRP.org/journal/ojepi/)

Changes in exercise habits and pulse wave velocity with lifestyle modification in Japanese

Nobuyuki Miyatake[1], Noriko Sakano[1], Takeshi Saito[2], Takeyuki Numata[2]

[1]Department of Hygiene, Faculty of Medicine, Kagawa University, Kagawa, Japan
[2]Okayama Southern Institute of Health, Okayama Health Foundation, Okayama, Japan
Email: miyarin@med.kagawa-u.ac.jp

Received 20 February 2012; revised 18 March 2012; accepted 2 April 2012

ABSTRACT

We investigated the changes in exercise habits and brachial-ankle pulse wave velocity (baPWV) with lifestyle modification in Japanese. We used data for 105 men (48.2 ± 13.8 years) and 110 women (48.6 ± 12.1 years) without any medications with a 1-year follow up. Subjects were given advice for dietary and lifestyle improvement. At the 1-year follow up, body weight and body mass index (BMI) were significantly decreased in both sexes. Abdominal circumference was significantly decreased in men. In addition, changes in exercise habits were noted in both sexes. In separate analysis in subjects without exercise habits at baseline, the changes in baPWV with exercise habits at follow up was lower than that without exercise habits at follow up in both sexes, but not at a significant level. Lifestyle modification may increase exercise habits, however, it did not evidently change baPWV in this population.

Keywords: Lifestyle Modification; baPWV; Exercise Habits

1. INTRODUCTION

Arterial stiffness represents one of the major hemodynamic factors determining pulse pressure even at an early stage of disease and its changes have been shown to be an independent predictor of hard endpoints in patients with a high cardiovascular risk. Pulse pressure and heart rate constitute other outcomes that may be useful as additional factors in risk assessment [1]. Pulse wave velocity (PWV) is measured from the initial upstroke of pressure wave and constitutes an established index of arterial stiffness. It is directly related to arterial compliance and other factors describing arterial stiffness [2]. PWV is not only a good tool for assessing vascular damage, but also an independent predictor of all-cause and cardiovascular mortality [3].

It is well known that regular physical activity has been shown to increase HDL and reduce resting blood pressure, triglycerides, abdominal fat accumulation, fasting blood sugar, and insulin responses to oral glucose challenge test [4-8]. The prevalence of subjects with exercise habits in Japan was reported to be 29.1% in men and 25.6% in women by the National Nutrition Survey in Japan [9]. Therefore, evaluation of the relationship between exercise habits and PWV may provide quite useful data for preventing future diseases in the Japanese general population.

In this study, we evaluated the changes in exercise habits and brachial-ankle PWV (baPWV) with lifestyle modification in Japanese without medications.

2. SUBJECTS AND METHODS

2.1. Subjects

We used data for 105 Japanese men (48.2 ± 13.8 years) and 110 Japanese women (48.6 ± 12.1 years) among 4200 subjects (1580 men and 2620 women), who met the following criteria: 1) received a health check-up including special health guidance (from April 2006 to August 2010) and a follow-up check-up 1-year later, 2) received anthropometric and exercise habits measurements as part of the annual health check-up, 3) received no medications for diabetes, hypertension, and/or dyslipidemia, and 4) provided written informed consent (**Table 1**).

At the first health check-up, all subjects were given instructions by well-trained medical staff on how to change their lifestyle as special health guidance. Nutritional instruction was provided with a well-trained nutriationist, who planned a diet for each subject based on their data and provided simple instructions (*i.e.* not to eat too much and to consider balance when they eat). Exercise instruction was also provided by a well-trained physical therapist, who encouraged each subject to increase their daily amount of steps walked.

Ethical approval for the study was obtained from the

Table 1. Changes in parameters of enrolled subjects.

	Baseline (Mean ± SD)	**Follow-up** (Mean ± SD)	*p*
Men			
Number of subjects	105		
Age	48.2 ± 13.8		
Height (cm)	170.5 ± 6.0		
Body weight (kg)	71.3 ± 11.6	70.0 ± 11.1	**0.0003**
Body mass index (kg/m^2)	24.5 ± 3.7	24.1 ± 3.4	**0.0002**
Abdominal circumference (cm)	85.6 ± 10.2	84.2 ± 9.6	**0.0033**
Hip circumference (cm)	95.1 ± 6.6	95.0 ± 8.1	0.8221
baPWV (right) (cm/s)	1329.1 ± 210.0	1326.8 ± 198.5	0.8261
baPWV (left) (cm/s)	1333.4 ± 217.9	1326.8 ± 196.4	0.5129
baPWV (mean) (cm/s)	1331.2 ± 212.4	1326.8 ± 195.2	0.6529
Women			
Number of subjects	110		
Age	48.6 ± 12.1		
Height (cm)	157.5 ± 5.0		
Body weight (kg)	54.3 ± 7.6	53.7 ± 7.5	**0.0171**
Body mass index (kg/m^2)	21.9 ± 3.1	21.7 ± 3.0	**0.0175**
Abdominal circumference (cm)	76.4 ± 8.7	76.8 ± 8.8	0.5053
Hip circumference (cm)	91.2 ± 5.2	90.6 ± 5.1	0.0623
baPWV (right) (cm/s)	1241.1 ± 189.1	1231.9 ± 182.8	0.3532
baPWV (left) (cm/s)	1258.6 ± 198.7	1254.3 ± 206.0	0.7391
baPWV (mean) (cm/s)	1249.9 ± 192.0	1243.1 ± 186.3	0.5147

Ethical Committee of Okayama Health Foundation.

2.2. Anthropometric Measurements

The anthropometric parameters were evaluated by using the following respective parameters such as height, body weight, body mass index (BMI), abdominal circumference, hip circumference. BMI was calculated by weight/[height]^2 (kg/m^2). The abdominal 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 [10].

2.3. PWV Measurements

The baPWV was measured using a form PWV/ABI (Colin, Co., Ltd., Komaki, Japan) after resting at least 15 minutes as described previously [11]. This instrument records PWV, blood pressure, electrocardiogram and heart sounds simultaneously. The subjects were examined in the spine position after at least 5 minutes rest, with electrocardiogram electrodes placed on both wrists, a microphone for detecting heart sounds placed on the left edge of the sternum, and cuffs wrapped on both the brachia and ankles. The cuffs were connected to a plethymographic sensor that determines volume pulse form and an oscillometric pressure sensor that measures blood pressure. Volume waveforms for the brachium and ankle were stored, and the sampling time was 10 s with automatic gain analysis and quality adjustment.

2.4. Exercise Habits

The data on exercise habits were obtained at interviews conducted by well-trained staff using the structured method of the National Nutrition Survey in Japan. The subjects were asked if they currently exercise (over 30 min per session, 2 times per week for duration of 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.

2.5. 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, χ^2 test and covariance analysis; $p < 0.05$ was considered to indicate statistical significance.

3. RESULTS

The clinical parameters at the baseline and the 1-year follow up are summarized in **Table 1**. Body weight, BMI and abdominal circumference were significantly reduced with lifestyle modification after one year in men. Body weight and BMI were also significantly reduced after one year in women. However, baPWV was reduced after one year in both sexes, but not at a significant level.

We also evaluated the changes in exercise habits in enrolled subjects (**Table 2**). Subjects with exercise habits were significantly increased in both sexes.

The changes in parameters in subjects without exercise habits at baseline were also investigated (**Table 3**). With lifestyle modification, body weight, BMI and abdominal circumference were significantly reduced with lifestyle modification after one year in men. Body weight and BMI were also significantly reduced after one year in women. However, baPWV was also reduced after one year in both sexes, but not at a significant level.

Finally, among subjects without exercise habits at baseline, we further compared the change in baPWV between subjects with and without exercise habits at follow up. The changes in baPWV in subjects with exercise habits at follow up were lower than those in subjects without exercise habits at follow up in both sexes, but not at a significant level even after adjusting for age (men: $p = 0.3204$, women: $p = 0.3462$) (**Table 4**).

4. DISCUSSION

The main objective of this study was to explore the changes in exercise habits and baPWV in apparently healthy Japanese with lifestyle modification with a 1-year follow up.

In some literatures, the link between exercise and PWV has been reported. Gando *et al.* have reported that

Table 2. Changes in exercise habits of enrolled subjects.

		Follow-up		p
		Exercise habits (+)	Exercise habits (–)	
Men				
Baseline	Exercise habits (+)	36	6	**0.0052**
	Exercise habits (–)	38	25	
Women				
Baseline	Exercise habits (+)	29	4	**< 0.0001**
	Exercise habits (–)	25	52	

Table 3. Changes in parameters of enrolled subjects without exercise habits at baseline.

	Baseline (Mean ± SD)	**Follow-up** (Mean ± SD)	p
Men			
Number of subjects	63		
Age	45.4 ± 12.4		
Height (cm)	171.9 ± 5.1		
Body weight (kg)	73.5 ± 12.2	71.9 ± 11.8	**0.0013**
Body mass index (kg/m^2)	24.9 ± 4.0	24.3 ± 3.9	**0.0011**
Abdominal circumference (cm)	87.4 ± 10.6	85.7 ± 10.5	**0.0092**
Hip circumference (cm)	96.5 ± 6.9	96.6 ± 9.5	0.8989
baPWV (right) (cm/s)	1313.4 ± 200.9	1302.7 ± 172.9	0.4220
baPWV (left) (cm/s)	1317.4 ± 207.6	1305.2 ± 22.9	0.3716
baPWV (mean) (cm/s)	1315.4 ± 202.3	1304.0 ± 175.3	0.3851
Women			
Number of subjects	77		
Age	49.0 ± 11.8		
Height (cm)	157.7 ± 4.7		
Body weight (kg)	54.6 ± 7.7	54.0 ± 7.3	**0.0357**
Body mass index (kg/m^2)	22.0 ± 3.2	21.8 ± 3.0	**0.0481**
Abdominal circumference (cm)	76.3 ± 8.8	77.1 ± 8.9	0.1943
Hip circumference (cm)	91.0 ± 5.4	90.7 ± 5.1	0.3186
baPWV (right) (cm/s)	1256.1 ± 197.8	1241.6 ± 184.9	0.2160
baPWV (left) (cm/s)	1270.1 ± 203.6	1270.0 ± 217.4	0.9916
baPWV (mean) (cm/s)	1263.1 ± 198.6	1255.8 ± 190.4	0.5532

Table 4. Comparison of changes in baPWV between subjects with and without exercise habits at follow up (subjects without exercise habits at baseline).

	Number of subjects	Mean ± SD	*p*	*p* (after adjusting for age)
Men				
Exercise habits (–) → (+)	38	–21.0 ± 99.0	0.3749	0.3204
Exercise habits (–) → (–)	25	3.0 ± 111.5		
Women				
Exercise habits (–) → (+)	25	–29.1 ± 101.1	0.2206	0.3462
Exercise habits (–) → (–)	52	3.2 ± 110.0		

longer time spent in light physical activity is associated with attenuation of arterial stiffening, especially in older people by cross-sectional analysis of 538 healthy Japanese [12]. Yamamoto K *et al.* also reported that baPWV was higher in poor-flexibility than in high-flexibility group [13]. In longitudinal analysis, Kawasaki *et al.* showed that a 6-month, twice-a-week exercise program emphasizing swimming significantly decreased baPWV in 11 men and 24 women [14]. Figueroa *et al.* also reported that a 12-week moderate-intensity combined circuit resistance and endurance exercise training improves arterial stiffness in 12 subjects [15]. In addition, home-based resistance training decreased baPWV in12 healthy premenopausal women [16]. In this study, with lifestyle modification at an annual health check-up, subjects with exercise habits were significantly increased. Among subjects without exercise habits, the changes in baPWV in subjects with exercise habits at follow up was more decreased than that in subjects without exercise habits at follow up, but not at a significant level. Therefore, it seems reasonable to suggest that simply promoting exercise habits might result in decrease baPWV in some Japanese.

Potential limitations remain in our study. First, the small sample size in our study makes it difficult to infer causality between exercise habits and baPWV. baPWV did not significantly change with a 1-year follow up. Possibly, these results may come from low statistical power and/or misclassification of life-style modification. Second, we also could not reveal the mechanism of the linkage between exercise habits and baPWV. Insulin resistance is associated with arterial stiffness independent of obesity [17]. Exercise habits may improve insulin resistance and baPWV. The third, the 105 men and 110 women among 4200 subjects, all of whom wanted to change their lifestyle, underwent measurements for this study: they were therefore more health-conscious than the average person. Further prospective and large sample size studies are required in Japanese subjects.

5. ACKNOWLEDGEMENTS

This research was supported in part by Health and Labor Sciences Research Grants from the Ministry of Health, Labor and Welfare, Japan.

REFERENCES

[1] Asmar, R., Darne, B., Assaad, M. and Topouchian, J. (2001) Assessment of outcomes other than systolic and diastolic blood pressure: pulse pressure, arterial stiffness and heart rate. *Blood Pressure Monitoring*, **6**, 329-333. doi:10.1097/00126097-200112000-00012

[2] Martyn, C.N. and Greenwald, S.E. (1996) Pulse wave velocity as a marker of vascular disease. *Lancet*, **348**, 1586. doi:10.1016/S0140-6736(05)66200-9

[3] Laurent, S., Boutouyrie, P., Asmar, R., Gautier, I., Laloux, B., Guize, L., Ducimetiere, P. and Benetos A. (2001) Aortic stiffness is an independent predictor of all-cause and cardiovascular mortality in hypertensive patients. *Hypertension*, **37**, 1236-1241.

[4] Miyatake, N., Takahashi, K., Wada, J., Nishikawa, H., Morishita, A., Suzuki, H., Kunitomi, M., Makino, H., Kira, S. and Fujii, M. (2003) Daily exercise lowers blood pressure and reduces visceral fat in overweight Japanese men. *Diabetes Research and Clinical Practice*, **62**, 149-157. doi:10.1016/S0168-8227(03)00176-1

[5] Miyatake, N., Nishikawa, H., Morishita, A., Kunitomi, M., Wada, J., Suzuki, H., Takahashi, K., Makino, H., Kira, S. and Fujii, M. (2002) Daily walking reduces visceral adipose tissue areas and improves insulin resistance in Japanese obese subjects. *Diabetes Research and Clinical Practice*, **58**, 101-107. doi:10.1016/S0168-8227(02)00129-8

[6] Barnard, R.J., Ugianskis, E.J., Martin, D.A., Inkeles, S.B. (1992) Role of diet and exercise in the management of hyperinsulinemia and associated atherosclerotic risk factors. *American Journal of Cardiology*, **69**, 440-444. doi:10.1016/0002-9149(92)90981-4

[7] Yamanouchi, K., Shinozaki, T., Chikada, K., Nishikawa, T., Ito, K., Shimizu, S., Ozawa, N., Suzuki, Y., Maeo, H., Kato, K., Oshida, Y. and Sato, Y. (1995) Daily walking combined with diet therapy is a useful means for obese NIDDM patients not only to reduce body weight but also to improve insulin sensitivity. *Diabetes Care*, **18**, 775-778. doi:10.2337/diacare.18.6.775

[8] Oshida, Y., Yamanouchi, K., Hayamizu, S. and Sato, Y. (1989) Long-term mild jogging increases insulin action despite no influence on body mass index or VO2 max.

Journal of Applied Physiology, **66**, 2206-2210.

[9] National Nutrition Survey in Japan (in Japanese) (2011). http://www.mhlw.go.jp/houdou/2008/12/dl/h1225-5i.pdf .

[10] Japanese Society of Internal Medicine (2005) Definition and the diagnostic standard for metabolic syndrome—Committee to Evaluate Diagnostic Standards for Metabolic Syndrome. *Nippon Naika Gakkai Zasshi*, **94**, 794-809. doi:10.2169/naika.94.794

[11] Kohara, K., Tabara, Y., Tachibana, R., Nakura, J. and Miki, T. (2004) Microalbuminuria and arterial stiffness in a general population: The Shimanami Health Promoting Program (J-SHIPP) Study. *Hypertension Research*, **27**, 471-477. doi:10.1291/hypres.27.471

[12] Gando, Y., Yamamoto, K., Murakami, H., Ohmori, Y., Kawakami, R., Sanada, K., Higuchi, M., Tabata, I. and Miyachi, M. (2010) Longer time spent in light physical activity is associated with reduced arterial stiffness in older adults. *Hypertension*, **56**, 540-546. doi:10.1161/HYPERTENSIONAHA.110.156331

[13] Yamamoto, K., Kawano, H., Gando, Y., Iemitsu, M., Murakami, H., Sanada, K., Tanimoto, M., Ohmori, Y., Higuchi, M., Tabata, I. and Miyachi M. (2009) Poor trunk flexibility is associated with arterial stiffening. *American Journal of Physiology*: *Heat and Circulatory Physiology*, **297**, 1314-1318.

[14] Kawasaki, T., Sullivan, C.V., Ozoe, N., Higaki, H. and Kawasaki, J. (2011) A long-term comprehensive exercise program that incorporates a variety of physical activities improved the blood pressure, lipid and glucose metabolism, arterial stiffness, and balance of middle-aged and elderly Japanese. *Hypertension Research*, **34**, 1059-1066. doi:10.1038/hr.2011.81

[15] Figueroa, A., Park, S.Y., Seo, D.Y., Sanchez-Gonzalez, M.A. and Baek, Y.H. (2011) Combined resistance and endurance exercise training improves arterial stiffness, blood pressure, and muscle strength in postmenopausal women. *Menopause*, **18**, 980-984. doi:10.1097/gme.0b013e3182135442

[16] Okamoto, T., Masuhara, M. and Ikuta, K. (2009) Home-based resistance training improves arterial stiffness in healthy premenopausal women. *European Journal of Applied Physiology*, **107**, 113-117. doi:10.1007/s00421-009-1102-x

[17] Lee, J.W., Lee, D.C., Im, J.A., Shim, J.Y., Kim, S.M. and Lee, H.R. (2007) Insulin resistance is associated with arterial stiffness independent of obesity in male adolescents. *Hypertension Research*, **30**, 5-11. doi:10.1291/hypres.30.5

Vol.4, No.9, 570-573 (2012)
doi:10.4236/health.2012.49089

The effect of cigarette smoking on flexibility in Japanese

Kanae Oda[1*], Nobuyuki Miyatake[1], Noriko Sakano[1], Takeshi Saito[1,2], Akihiko Katayama[1], Kenji Nishii[3], Takeyuki Numata[2]

[1]Department of Hygiene, Faculty of Medicine, Kagawa University, Kagawa, Japan;
[*]Corresponding Author: oda@med.kagawa-u.ac.jp
[2]Okayama Southern Institute of Health, Okayama Health Foundation, Okayama, Japan
[3]Okayama Health Foundation Hospital, Okayama, Japan

Received 19 July 2012; revised 18 August 2012; accepted 31 August 2012

ABSTRACT

To investigate the link between cigarette smoking and flexibility in the Japanese population, we used data of 4234 men and 9169 women, aged 20 - 79 years, in this cross-sectional investigation study. Flexibility such as sit and reach were measured. In addition, habits of cigarette smoking and exercise were obtained by well-trained medical staff. The effect of cigarette smoking on flexibility was evaluated. A total of 1613 men (38.1%) and 995 women (10.9%) were having habits of cigarette smoking. Flexibility in men was decreased with aging and that in women increased with aging under 60's. Flexibility in subjects with cigarette smoking was significantly lower than that in subjects without cigarette smoking even after adjusting for age and exercise habits in both sexes. Cigarette smoking might be modifiable factor of flexibility in the Japanese.

Keywords: Cigarette Smoking; Flexibility; Exercise Habits

1. INTRODUCTION

Cigarette smoking is a public health problem, and it has been reported that 32.2% in men and 8.4% in women are current smokers in Japan [1]. Cigarette smoking has also reported to be a strong risk factor for atherosclerosis and cardiovascular disease in a dose-dependent manner [2].

In 2006 in Japan, levels of maximal oxygen uptake and muscle strength were recommended as exercise and physical activity reference quantity for health promotion 2006 (EPARQ2006) by the Ministry of Health, Labor and Welfare, Japan [3] However, optimal value of the flexibility was not recommended [3] and the link between cigarette smoking and flexibility in a large sample of Japanese has not yet been fully discussed.

Therefore, in this study, we evaluated the effect of cigarette smoking on flexibility in the Japanese.

2. SUBJECTS AND METHODS

2.1. Subjects

We used data of 4234 men (43.3 ± 13.9 years) and 9169 women (42.4 ± 13.9 years) in a cross-sectional study. Subjects met the following criteria (**Table 1**): 1) they underwent an annual health check-up from June 1999 to November 2009 at Okayama Southern Institute of Health; 2) they had flexibility, exercise habits and cigarette smoking evaluated as part of their annual health check-up; and 3) all subjects provided written informed consent for the use of their data in the study.

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

2.2. Anthropometric Measurements

The anthropometric parameters were evaluated by using the following respective parameters such as height, body weight, body mass index (BMI), abdominal circumference and hip circumference. BMI was calculated by weight/[height]^2 (kg/m^2). The abdominal 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 [4].

2.3. Cigarette Smoking

The data on cigarette smoking was obtained at interviews by well-trained staff in a structured way. The subjects were asked if they currently smoked cigarettes. When the answer was "yes", they were classified as current smokers. When the answer was "no", they were classified as non-smokers.

2.4. Flexibility

The flexibility of all the participants was measured as follows. Sit-and-reach measurements were obtained to assess the overall flexibility in the forward flexion, with the measurements recorded as the distance (in centimeters) between the fingertips and toes. The subject's knees were kept straight throughout the test and ankles were maintained at 90 degrees by having the soles of the feet pressed against a board perpendicular to the sitting surface [5].

2.5. Exercise Habits

The data on exercise habits were obtained at interviews conducted by well-trained staff using the structured method of the National Nutrition Survey in Japan. The subjects were asked if they currently exercise (over 30 min per session, 2 times per week for duration of 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.

2.6. Statistical Analysis

Data are expressed as means ± standard deviation (SD) values. A comparison of parameters was made using the unpaired *t*-test, χ^2 test, one-factor ANOVA, Sheffes'F test, covariance analysis and logistic regression analysis; where $p < 0.05$ was considered to indicate statistical significance.

3. RESULTS

Clinical profiles of enrolled subjects were summarized in **Table 1**. Flexibility was 2.9 ± 10.1 cm in men and 9.5 ± 8.9 cm in women. A total of 1613 men (38.1%) and 995 women (10.9%) were having habits of cigarette smoking (**Table 2**) and the prevalence of subjects with cigarette smoking decreased with aging.

Changes in flexibility as classified by age groups were evaluated. In men, flexibility was significantly decreased with aging. However, flexibility was significantly increased with aging under 60's in women (**Table 3**). In addition, it is well known that exercise habits were closely associated with cigarette smoking [6]. Therefore, we evaluated the relationship between cigarette smoking and exercise habits (**Table 4**). Significant relationship between cigarette smoking and exercise habits was noted in both sexes.

Finally, we compared flexibility between subjects with and without cigarette smoking (**Table 5**). Flexibility in subjects with cigarette smoking was significantly lower than that in subjects without cigarette smoking. The differences were remained even after adjusting for age and exercise habits.

Table 1. Clinical profiles of enrolled subjects.

	Men			Women		
	Mean ± SD	Minimum	Maximum	Mean ± SD	Minimum	Maximum
Number of subjects	4234			9169		
Age	43.3 ± 13.9	20	79	42.4 ± 13.9	20	79
Height (cm)	169.0 ± 6.2	145.3	190.9	156.3 ± 5.7	134.3	179.3
Body weight (kg)	70.4 ± 11.7	39.1	175.7	55.1 ± 9.0	32.1	116.9
Body mass index (kg/m^2)	24.6 ± 3.6	13.6	61.5	22.6 ± 3.6	12.9	48.7
Abdominal circumference (cm)	84.3 ± 10.2	58.0	157.0	72.1 ± 9.6	43.3	123.6
Hip circumference (cm)	94.2 ± 6.3	71.0	145.5	91.0 ± 6.0	58.5	132.0
Flexibility (cm)	2.9 ± 10.1	–38.0	33.6	9.5 ± 8.9	–35.5	35.8

Table 2. Prevalence of subjects with cigarette smoking.

	Men		Women	
	Number of subjects	%	Number of subjects	%
20 - 29	379	44.4	388	17.2
30 - 39	434	42.3	269	13.6
40 - 49	375	41.8	202	10.8
50 - 59	390	36.8	103	5.7
60 - 69	113	20.9	32	3.0
70 - 79	22	16.8	1	0.5
Total	1613	38.1	995	10.9

Table 3. Changes in flexibility as classified by age groups.

	Men		Women	
	Mean ± SD	p	Mean ± SD	p
20 - 29	4.9 ± 9.9		8.0 ± 9.6	
30 - 39	3.3 ± 10.3	a	9.2 ± 9.0	a
40 - 49	3.3 ± 9.9	a	9.8 ± 8.6	a
50 - 59	1.8 ± 9.7	a	10.3 ± 8.5	ab
60 - 69	1.0 ± 9.7	abc	11.3 ± 8.0	abc
70 - 79	−1.4 ± 11.7	abcd	9.9 ± 8.4	

a: $p < 0.05$ vs 20 - 29; b: $p < 0.05$ vs 30 - 39; c: $p < 0.05$ vs 40 - 49; d: $p < 0.05$ vs 50 - 59.

Table 4. Relationship between cigarette smoking and exercise habits.

	Exercise habits (+)	Exercise habits (–)	p
Men			
Cigarette smoking (+)	424	1189	**<0.0001**
Cigarette smoking (–)	1056	1565	
Women			
Cigarette smoking (+)	147	848	**<0.0001**
Cigarette smoking (–)	2279	5895	

Table 5. Comparison of flexibility between subjects with and without cigarette smoking.

	Number of subjects	Mean ± SD	p	p (After adjusting for age)	p (After adjusting for age, exercise habits)
Men					
Cigarette smoking (+)	1613	2.2 ± 10.2	**0.0002**	**0.0500**	**<0.0001**
Cigarette smoking (–)	2621	3.3 ± 10.0			
Women					
Cigarette smoking (+)	995	7.9 ± 9.8	**<0.0001**	**0.0342**	**<0.0001**
Cigarette smoking (–)	8174	9.7 ± 8.8			

4. DISCUSSION

The main finding of this study is that cigarette smoking was might be modifiable factor of flexibility in the Japanese population.

In some literatures, the relationship between cigarette smoking and flexibility has been showed [7-9]. Conway has reported that they examined 1357 Navy men and fitness was negatively associated with cigarette smoking [7]. Boyce *et al.* also showed that smokers had signifycantly lower fitness scores in sit and reach flexibility in 514 police officers [8]. However, Ricci *et al.* reported that there were significant differences for age and flexibility in relation to the history of smoking *i.e.* ex-smoking women were shown to be younger and be more flexible than those who had never smoked [9]. They did not adjust for age when they compare flexibility between subjects with and without cigarette smoking. In this study, we solely evaluated the relationship between cigarette smoking and flexibility *i.e.* sit-and-reach measurements in Japanese. Exercise habits were closely linked to cigarette smoking and the differences flexibility between subjects with and without cigarette smoking were not attenuated even after adjusting for age and exercise habits. We have also reported that aerobic exercise level defined by ventilatory threshold was associated with cigarette smoking in Japanese [6]. Sedentary lifestyle may contribute to the functional decline of subjects and cigarette smoking may accelerate alterations in several systems and organic functions. Poor trunk flexibility is associated with arterial stiffening [10]. Taken together, a combination of promoting exercise habits and prohibiting cigarette smoking might be considered for improving flexibility in Japanese.

Potential limitations still remain in this study. First, our study was a cross sectional and not a longitudinal study. Second, 4234 men and 9169 women in our study voluntarily underwent measurements: they were therefore more likely to be health-conscious compared with the average person. Third, the difference of changes in flexibility between men and women with aging were noted. Forth, we could not clarify the mechanism of the link between cigarette smoking and flexibility. Smokers often show lower levels of current and past leisure-time physical activity, hormonal disorders and nutritional deficits [11]. However, it seems reasonable to suggest that prohibiting smoking might result in the amelioration of flexibility in some Japanese. To show this, further prospective studies are needed in the Japanese population.

5. ACKNOWLEDGEMENTS

This research was supported in part by Research Grants from the Ministry of Health, Labor, and Welfare, Japan. There is no conflict of interest.

REFERENCES

[1] Ministry of Health, Labor and Welfare, Japan (2012) The national nutrition survey in Japan. http://www.mhlw.go.jp/stf/houdou/2r98520000020qbb-att/2r98520000021c19.pdf (in Japanese)

[2] Peto, R. (1994) Smoking and death: The past 40 years and the next 40. *British Medical Journal*, **209**, 937-939. doi:10.1136/bmj.309.6959.937

[3] Ministry of Health, Labor and Welfare, Japan (2012) Exercise and physical activity reference quantity for health promotion 2006. http://www.mhlw.go.jp/shingi/2006/07/dl/s0719-3b.pdf (in Japanese)

[4] Committee to Evaluate Diagnostic Standards for Metabolic Syndrome (2005) Definition and the diagnostic standard for metabolic syndrome—Committee to Evaluate Diagnostic Standards for Metabolic Syndrome. *Nippon Naika Gakkai Zasshi*, **94**, 794-809. (in Japanese) doi:10.2169/naika.94.794

[5] Miyatake, N., Miyachi, M., Tabata, I. and Numata, T. (2012) Evaluation of anthropometric parameters and physical fitness in elderly Japanese. *Environmental Health and Preventive Medicine*, **17**, 62-68. doi:10.1007/s12199-011-0220-3

[6] Miyatake, N., Numata, T., Nishii, K., Sakano, N., Suzue, T., Hirao, T., Miyachi, M. and Tabata, I. (2011) Realtion between cigarette smoking and ventilatory threshold in the Japanese. *Environmental Health and Preventive Medicine*, **16**, 185-190. doi:10.1007/s12199-010-0178-6

[7] Conway, T. L. (1989) Behavioral, psychological, and demographic predictors of physical fitness. *Psychological Reports*, **65**, 1123-1135. doi:10.2466/pr0.1989.65.3f.1123

[8] Boyce, R. W., Perko, M. A., Jones, G. R., Hiatt, A. H. and Boone, E. L. (2006) Physical fitness, absenteeism and workers' compensation in smoking and non-smoking police officers. *Occupational Medicine (Lond)*, **56**, 353-356. doi:10.1093/occmed/kql057

[9] Ricci, N. A., Francisco, C. O., Rebelatto, M. N. and Rebelatto, J. R. (2011) Influence of history of smoking on the physical capacity of older people. *Archieves of Gerontology and Geriatrics*, **52**, 79-83. doi:10.1016/j.archger.2010.02.004

[10] Yamamoto, K., Kawano, H., Gando, Y., Iemitsu, M., Murakami, H., Sanada, K., Tanimoto, M., Ohmori, Y., Higuchi, M., Tabata, I. and Miyachi, M. (2009) Poor trunk flexibility is associated with arterial stiffening. *American Journal of Physiology-Heart and Circulatory Physiology*, **297**, H1314-H1318. doi:10.1152/ajpheart.00061.2009

[11] Szulc, P., Duboeuf, F., Marchand, F. and Delmas, P. D. (2004) Hormonal and lifestyle determinants of appendicular skeletal muscle mass in men: The MINOS study. *The American Journal of Clinical Nutrition*, **80**, 496-503.

Original Article

J Prev Med Public Health 2012;45:381-386 • http://dx.doi.org/10.3961/jpmph.2012.45.6.381

pISSN 1975-8375 eISSN 2233-4521

Journal of
Preventive Medicine
& Public Health

Relationship Between Cigarette Smoking and Muscle Strength in Japanese Men

Takeshi Saito[1,2], Nobuyuki Miyatake[1], Noriko Sakano[1], Kanae Oda[1], Akihiko Katayama[1], Kenji Nishii[3], Takeyuki Numata[2]

[1]*Department of Hygiene, Faculty of Medicine, Kagawa University, Kagawa;* [2]*Okayama Southern Institute of Health, Okayama Health Foundation, Okayama;* [3]*Okayama Health Foundation Hospital, Okayama, Japan*

Objectives: To investigate the link between cigarette smoking and muscle strength in Japanese men.

Methods: We used data on 4249 Japanese men, aged 43.3±13.9 years, in this cross-sectional investigation study. Grip strength and leg strength were measured as indicators of overall muscle strength. Meanwhile, subjects' cigarette smoking habits were recorded by trained medical staff. The effect of cigarette smoking on muscle strength was evaluated.

Results: A total of 1618 men (38.1%) were smokers and 1481 men (34.9%) exercised regularly. Significant differences in muscle strength were noted between men with and without a Brinkman index of 400 or greater, after adjusting for age. After adjusting for age, height, body weight and exercise habits, associations between the Brinkman index and leg strength and the ratio of leg strength to body weight were attenuated.

Conclusions: Cigarette smoking might be negatively associated with muscle strength, especially grip strength in Japanese men.

Key words: Smoking, Muscle strength, Grip strength, Leg, Exercise

INTRODUCTION

Cigarette smoking is a worldwide public health challenge, and it has been reported that, in Japan, 32.2% of men and 8.4% of women are current smokers [1]. Cigarette smoking is also a strong risk factor for atherosclerosis and cardiovascular disease in a dose-dependent manner [2]. Therefore, curbing smoking habits is urgently necessary.

It is also well known that low and declining muscle strength is linked to increased mortality, independent of physical activity and muscle mass [3]. Levels of maximal oxygen uptake (aerobic exercise level) and muscle strength were recommended by as the Exercise and Physical Activity Reference Quantity for Health Promotion 2006 study sponsored by Japan's Ministry of Health, Labour and Welfare [4]. In a previous study, we demonstrated that aerobic exercise level and cigarette smoking are closely linked [5], and suggested that curbing smoking habits was would be useful for increasing aerobic exercise level. Therefore, smoking habits may also affect muscle strength. Although resistance training has also been advocated as the most suitable exercise for increasing muscle strength [6,7], the link between cigarette smoking and muscle strength in a large sample of Japanese has not yet been fully discussed. In this study, we evaluated the effect of cigarette smoking on muscle strength in Japanese men.

Received: June 22, 2012 Accepted: September 11, 2012
Corresponding author: Nobuyuki Miyatake, MD
1750-1 Ikenobe, Miki-cho, Kita-gun, Kagawa 761-0793, Japan
Tel: +81-87-891-2465, Fax: +81-87-891-2134
E-mail: miyarin@med.kagawa-u.ac.jp

METHODS

Subjects

We used data on 4249 men (43.1±13.9 years), aged 20 to 79 years, in a cross-sectional study. Subjects met the following criteria: 1) they underwent an annual health check-up from June 1999 to November 2009 at the Okayama Southern Institute of Health, 2) as part of their annual health check-up, they had muscle strength, exercise habits and smoking habits evaluated, 3) all subjects provided written informed consent for the use of their data in the study (Table 1). Ethical approval for the study was obtained from the Ethics Committee of the Okayama Health Foundation.

Anthropometric Measurements

The anthropometric parameters were evaluated by using the indicators of height, body weight, body mass index (BMI), abdominal circumference, and hip circumference. BMI was calculated by weight/(height)^2 (kg/m^2). The abdominal 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.

Cigarette Smoking

The data on cigarette smoking was obtained through structured interviews conducted by public health nurses trained for this study. The subjects were asked if they currently smoked cigarettes. When the answer was 'yes', they were classified as current smokers and further questions were asked regarding the average number of cigarettes smoked per day and at what age they started smoking. In the case of a 'no' answer, they were classified as non smokers. We could not classify those who used to smoke but had since stopped smoking.

Based on answers to those questions, the cumulative amount of cigarette consumption was expressed as the Brinkman index (number of cigarette consumed per day multiplied by years of smoking) [8]. A Brinkman index greater than or equal to 400 was classified as a heavy current smoker and less than 400 was a light current smoker.

Table 1. Clinical profiles and comparison of parameters between smoking and non-smoking subjects

	Current smokers	Nonsmokers	*p*-value
No. of subjects	1618	2631	
Age	40.8±12.5	44.9±14.5	<0.001
Height (cm)	169.6±5.9	168.7±6.3	<0.001
Body weight (kg)	70.8±12.1	70.1±11.4	0.03
Body mass index (kg/m^2)	24.6±3.8	24.6±3.5	0.99
Right grip strength (kg)	44.9±8.0	43.3±8.4	<0.001
Left grip strength (kg)	42.9±7.6	41.2±8.0	<0.001
Leg strength (kg)	66.6±16.9	64.8±17.5	0.001
Leg strength/body weight	0.95±0.22	0.93±0.23	0.01
Subjects with exercise habits	424 (28.6%)	1057 (71.4%)	<0.001

Values are presented as mean±SD.

Muscle Strength

To assess muscle strength, grip and leg strength were measured [9]. Grip strength and leg strength were measured using a dynamometer suited for each measurement (THP-10, Sakai, Tokyo, Japan; COMBIT CB-1, Minato, Osaka, Japan; respectively). Isometric leg strength was measured by seating the subject in a chair, instructing him or her to grasp the armrests to fix the body position, and then instructing the subject to extend his or her leg to 60° with a dynamometer attached to the ankle joint by a strap. More detailed descriptions of the procedure have been published in previous reports [9,10], which have also shown the accuracy of this type of measurement [10]. All muscle strength measurements were recorded in 2 trials; the strongest performance was the one used for analysis. To standardize the influence of body weight, we calculated the ratio of leg strength to body weight; a ratio of 1.0 kilogram in leg strength per kilogram body weight has been a standard in past studies [10].

Exercise Habits

Using the structured method of the National Nutrition Survey in Japan, data on exercise habits were obtained through structured interviews conducted by staff trained for this study. The subjects were asked if they currently exercise (over 30 minutes per session, 2 times per week for a duration of 3 months). When the answer was 'yes,' they were classified as subjects with regular exercise habits. When the answer was 'no,' they were classified as subjects without regular exercise habits.

Statistical Analysis

Data are expressed as means±standard deviation values. A comparison of parameters, that is, age, and anthropometric and muscle strength parameters, between smoking and non-smoking subjects was made using the unpaired *t*-test. Covariance analysis was used to adjust for age, and a multiple logistic regression analysis and odds ratio was also used and adjusted for various potential confounders; $p<0.05$ was considered to indicate statistical significance. Correlation coefficients were calculated and used to test the significance of the linear relationship between muscle strength and the Brinkman index. In addition, a partial correlation coefficient was calculated to adjust for age, height and body weight.

RESULTS

Clinical profiles and a comparison of parameters between smoking and nonsmoking subjects are summarized in Table 1. A total of 1618 men (38.1%) had smoking habits and 1481 men (34.9%) had exercise habits. Height, body weight, and muscle strength parameters were significantly higher, while age and exercise habits were significantly lower, in current smokers than in nonsmokers. We compared muscle strength between smoking and nonsmoking men classified by age group (Table 2). Among men in their 20's, those who smoked had significantly higher left-hand grip strength significantly lower leg strength/body weight than those who did not smoke. Among men in their 30's, those who smoked also had significantly higher left-hand grip strength than those who did not smoke. However, differences such as these were not noted among any other age groups.

We also investigated the relationship between cigarette smoking and muscle strength (Table 3). The Brinkman index (n=1618, 499±406) was weakly and negatively correlated with parameters of muscle strength, that is, grip strength, leg strength and leg strength/body weight. After adjusting for age, height, and body weight, however, no clear relationship, expressed as a partial correlation coefficient, was noted be-

Table 2. Comparison of muscle strength between smoking and non-smoking men by age group

	Current smokers	Nonsmokers	*p*-value
20-29 y			
No. of subjects	379	477	
Right grip strength (kg)	47.3±7.7	46.4±7.6	0.10
Left grip strength (kg)	44.8±7.5	43.8±7.3	0.05
Leg strength (kg)	71.6±16.3	72.7±16.7	0.33
Leg strength/body weight	1.02±0.22	1.06±0.23	0.01
30-39 y			
No. of subjects	437	591	
Right grip strength (kg)	46.7±7.2	45.9±7.7	0.11
Left grip strength (kg)	44.6±7.0	43.6±7.3	0.02
Leg strength (kg)	69.7±16.7	71.1±16.8	0.17
Leg strength/body weight	0.98±0.21	1.00±0.23	0.19
40-49 y			
No. of subjects	375	526	
Right grip strength (kg)	45.7±7.4	45.3±7.8	0.45
Left grip strength (kg)	43.8±6.9	43.5±7.3	0.44
Leg strength (kg)	68.6±15.3	67.7±16.2	0.41
Leg strength/body weight	0.96±0.21	0.94±0.21	0.16
50-59 y			
No. of subjects	292	598	
Right grip strength (kg)	42.1±7.1	42.4±7.5	0.62
Left grip strength (kg)	40.3±6.7	40.5±7.5	0.82
Leg strength (kg)	60.7±14.8	61.6±14.4	0.41
Leg strength/body weight	0.88±0.19	0.89±0.19	0.46
60-69 y			
No. of subjects	113	429	
Right grip strength (kg)	36.8±6.9	37.4±6.8	0.43
Left grip strength (kg)	36.0±6.5	36.0±6.6	0.99
Leg strength (kg)	51.4±12.4	53.2±13.0	0.19
Leg strength/body weight	0.79±0.18	0.81±0.19	0.36
70-79 y			
No. of subjects	22	110	
Right grip strength (kg)	33.5±7.4	32.3±7.0	0.45
Left grip strength (kg)	31.3±7.3	30.7±6.7	0.71
Leg strength (kg)	41.3±12.2	41.6±10.5	0.85
Leg strength/body weight	0.69±0.19	0.66±0.18	0.49

Values are presented as mean±SD.

Table 3. Relationship between muscle strength and Brinkman index

	Correlation coefficient	Partial correlation coefficient[1]
Right grip strength (kg)	-0.208	0.020
Left grip strength (kg)	-0.197	0.012
Leg strength (kg)	-0.200	0.010
Leg strength/body weight	-0.208	0.013

[1]Adjusting for age, height and body weight.

Table 4. The relationship between cigarette smoking and exercise habits

	Regular exercise habits	No exercise habits	*p*-value	*p*-value[1]
Current smokers	424 (26.2)	1194 (73.8)	<0.001	<0.001
Nonsmokers	1057 (40.2)	1574 (59.8)		

Values are presented as number (%).
[1]Adjusting for age, height and body weight.

tween the Brinkman Index and muscle.

We also evaluated the relationship between smoking habits and exercise habits (Table 4). Men who smoked cigarettes were significantly less likely to have exercise habits (424 men, 26.2%) than those who do not smoke (1057 men, 40.2%), even after adjusting for age, height, and body weight.

We compared muscle strength between men along their classification by the Brinkman index (Table 5). Parameters of muscle strength, that is, grip strength, leg strength, and leg strength/body weight in men with a Brinkman index greater than or equal to 400 were significantly lower than those in men with a Brinkman index less than 400. Significant differences in grip strength were remained even after adjusting for age, height, body weight, and exercise habits. However, differences in leg strength and leg strength/body weight were attenuated and not statistically significant after adjusting for age, height, body weight, and exercise habits. Finally, we investigated the relationship between each of three types of smoking habits (non smoker; light current smoker, Brinkman index <400; heavy current smoker, ≥400 Brinkman index) and muscle strength (Table 6). Even after adjusting for age, height, body weight, and exercise habits, a significant relationship between smoking habits and grip strength was noted by logistic regression analysis.

Table 5. Comparison of muscle strength between smokers by Brinkman index

	Brinkman index ≥400	Brinkman index <400	*p*-value	*p*-value[1]	*p*-value[2]
No. of subjects	847	771			
Right grip strength (kg)	43.8±8.0	46.2±7.8	<0.001	<0.001	0.004
Left grip strength (kg)	41.9±7.5	44.1±7.5	<0.001	<0.001	0.001
Leg strength (kg)	64.0±16.7	69.5±16.6	<0.001	<0.001	0.37
Leg strength/ body weight	0.91±0.21	0.99±0.22	<0.001	0.03	0.38

[1]Adjusting for age.
[2]Adjusting for age, height, body weight, and exercise habits.

DISCUSSION

The main finding of this study was that cigarette smoking was associated with muscle strength in Japanese men. The relationship between cigarette smoking and muscle strength has been studied previously [11-13]. Kumar and Kumar [11] have reported that muscle strength, as measured by the Kraus-Weber physical fitness test, showed a significant decrease in cigarette-smoking athletes ages 19 to 30 years, compared to nonsmoking athletes. Lee et al. [12], in their cross-sectional study of sarcopenia in 4000 community-dwelling older Chinese men and women was associated with cigarette smoking, chronic illness, physical inactivity, underweight, poorer physical strength in the upper limbs, as well as poorer overall well-being. In a longitudinal study, Kok et al. [13] reported that knee muscle strength was inversely associated with cigarette smoking. In addition, smoking 100 g a week resulted in a reduction of 2.9% knee muscle strength in men and a reduction of 5.0% in women.

In this study, we solely evaluated the relationship between cigarette smoking and grip strength, leg strength, and leg strength/body weight in Japanese men. Without adjusting for confounding factors, muscle strength in cigarette-smoking men, was higher than that in men who did not smoke. However, such differences were attenuated when factoring in age group, particularly among the elderly groups of subjects. The maximum of the differences in strength between current smokers and non smokers were almost 1 kg in each age group. According to the National Nutrition Survey in Japan, the prevalence of subjects with exercise habits increases with age, while daily step counts and smoking habits decrease with age [14]. Thus, lower exercise intensity and shorter exercise time in elderly adults, in addition to smoking habits, may have affected our results.

It is well known that exercise habits are closely associated with muscle strength [15]. Exercise habits were also closely

Table 6. Relationship between degree of smoking and muscle strength by logistic regression analysis

	Right grip strength (kg)	Left grip strength (kg)	Leg strength (kg)	Leg strength/body weight
Current smokers (400≤Brinkman index)	1.0 (reference)	1.0 (reference)	1.0 (reference)	1.0 (reference)
Current smokers (Brinkman index <400)	0.983 (0.968, 0.998)	0.987 (0.971, 1.002)	0.993 (0.985, 1.000)	0.609 (0.360, 1.031)
Nonsmokers	0.974 (0.963, 0.986)	0.971 (0.960, 0.983)	0.997 (0.991, 1.003)	0.819 (0.548, 1.224)

Data are expressed as odds ratio (95% confidence interval).
Adjusting for age, height, body weight, and exercise habits.

linked to cigarette smoking in this study. After adjusting for muscle confounding factors, including exercise habits, grip strength in current smokers with a Brinkman index greater than 400 was significantly lower than that in current smokers with an index of less than 400. In turn, differences in leg strength and leg strength/body weight were attenuated and not statistically significant after adjusting for age, height, body weight, and exercise habits.

The reasons for this discrepancy between leg strength and grip strength are not clear. Perhaps leg strength is employed more in daily life than in grip strength. The difference in daily usage might affect these results. We have also reported that aerobic exercise level defined by ventilatory threshold was associated with cigarette smoking in Japanese [5]. Taken together, the degree of smoking in heavy current smokers may affect muscle strength, especially grip strength. A combination of promoting exercise habits and prohibiting smoking habits should be considered for improving muscle strength in Japanese men.

Potential limitations remain in this study. First, our study was a cross sectional and not a longitudinal study. Second, 4249 men in our study voluntarily underwent measurements: They were therefore more likely to be health-conscious compared with the average person. Third, we could not show a clear relationship between cigarette smoking and muscle strength in men. Fourth, we did not evaluate women. Fifth, we could not identify the mechanism that the links cigarette smoking and muscle strength. Smokers often have hormonal disorders, nutritional deficits, and lower levels of current and past leisure-time physical activity [16]. In addition, those are potential factors that may influence muscle strength and could not be evaluated in this study.

Nonetheless, it seems reasonable to suggest that prohibiting smoking and promoting exercise habits might result in improved muscle strength in some Japanese men. To demonstrate this clearly, further prospective studies of the Japanese are needed.

ACKNOWLEDGEMENTS

This research was supported in part by Research Grants from the Ministry of Health, Labor, and Welfare, Japan.

CONFLICT OF INTEREST

The authors have no conflicts of interest with the material presented in this paper.

REFERENCES

1. Ministry of Health, Labour and Welfare. The national nutrition survey in Japan [cited 2012 May 19]. Available from: http://www.mhlw.go.jp/stf/houdou/2r98520000020qbb-att/2r98520000021c19.pdf (Japanese).
2. Peto R. Smoking and death: the past 40 years and the next 40. BMJ 1994;309(6959):937-939.
3. Metter EJ, Talbot LA, Schrager M, Conwit R. Skeletal muscle strength as a predictor of all-cause mortality in healthy men. J Gerontol A Biol Sci Med Sci 2002;57(10):B359-B365.
4. Ministry of Health, Labour and Welfare. Exercise and physical activity reference quantity for health promotion 2006 [cited 2012 May 19]. Available from: http://www.mhlw.go.jp/shingi/2006/07/dl/s0719-3b.pdf (Japanese).
5. Miyatake N, Numata T, Nishii K, Sakano N, Suzue T, Hirao T, et al. Relation between cigarette smoking and ventilatory threshold in the Japanese. Environ Health Prev Med 2011;16(3):185-190.
6. Geliebter A, Maher MM, Gerace L, Gutin B, Heymsfield SB, Hashim SA. Effects of strength or aerobic training on body composition, resting metabolic rate, and peak oxygen consumption in obese dieting subjects. Am J Clin Nutr 1997;66(3):557-563.
7. Rhodes EC, Martin AD, Taunton JE, Donnelly M, Warren J, Elliot J. Effects of one year of resistance training on the relation between muscular strength and bone density in elderly women. Br J Sports Med 2000;34(1):18-22.
8. Brinkman GL, Coates EO Jr. The effect of bronchitis, smoking, and occupation on ventilation. Am Rev Respir Dis 1963;87:684-693.
9. Miyatake N, Wada J, Saito T, Nishikawa H, Matsumoto S, Miyachi M, et al. Comparison of muscle strength between Japanese men with and without metabolic syndrome. Acta Med Okayama 2007;66(2):99-102.
10. Kigawa A, Yamamoto T, Koyama Y, Kageyama S, Arima K. Evaluation of knee extensor strength for prevention of sports injury. Jpn Orthop Soc Sports Med 1987;6:141-145 (Japanese).
11. Kumar PR, Kumar NV. Effect of cigarette smoking on muscle strength of flexibility of athletes. Indian J Exp Biol 1998;36(11):

1144-1146.

12. Lee JS, Auyeung TW, Kwok T, Lau EM, Leung PC, Woo J. Associated factors and health impact of sarcopenia in older chinese men and women: a cross-sectional study. Gerontology 2007; 53(6):404-410.
13. Kok MO, Hoekstra T, Twisk JW. The longitudinal relation between smoking and muscle strength in healthy adults. Eur Addict Res 2012;18(2):70-75.
14. Ministry of Health, Labour and Welfare, Japan. The national nutrition survey in Japan [cited 2012 Aug 14]. Available from: http://www.mhlw.go.jp/houdou/2008/04/dl/h0430-2g.pdf (Japanese).
15. Miyatake N, Saito T, Miyachi M, Tabata I, Numata T. Evaluation of muscle strength and its relation to exercise habits in Japanese. Acta Med Okayama 2009;63(3):151-155.
16. Szulc P, Duboeuf F, Marchand F, Delmas PD. Hormonal and lifestyle determinants of appendicular skeletal muscle mass in men: the MINOS study. Am J Clin Nutr 2004;80(2):496-503.

厚生労働科学研究費補助金

循環器疾患・糖尿病等生活習慣病対策総合研究事業

健康づくりのための運動基準・運動指針改定ならびに

普及・啓発に関する研究

（H２２−循環器（生習）−指定−０２１）

平成２４年度　総括・分担研究報告書（別冊）

研究代表者　宮地　元彦

平成２５年（2013）年３月

上巻

厚生労働科学研究費補助金

循環器疾患・糖尿病等生活習慣病対策総合研究事業

健康づくりのための運動基準・運動指針改定ならびに普及・啓発に関する研究

（H２２−循環器（生習）−指定−０２１）

平成２４年度　総括・分担研究報告書（別冊）

研究代表者　宮地　元彦

平成２５年（2013）年３月