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.

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

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.

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. Covari-

ance 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.

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.

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 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.