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Abstract

The aim of this study was to explore muscle strength and its relation to exercise habits in Japanese. We used data from 3,018 men and 6,881 women aged 20-69 years and not using medications in a cross-sectional study. Exercise habits and muscle strength, i.e. grip strength and leg strength, were measured. Age-related changes in muscle strength were noted. Exercise habits were found in 984 men (32.6%) and 1,664 women (24.2%). For subjects of both sexes over 50 years, grip strength was significantly decreased with age. However, the ratio of leg strength to body weight significantly decreased with age as early as 30 years in men and 40 years in women. Grip strength, leg strength and the ratio of leg strength to body weight in subjects with exercise habits were significantly higher than those without exercise habits after adjusting for age in both sexes. This standard mean value may provide a useful database for evaluating muscle strength in Japanese adult subjects.

KEYWORDS: exercise habits, grip strength, leg strength

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Original Article

Evaluation of Muscle Strength and Its Relation to Exercise Habits in Japanese

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The aim of this study was to explore muscle strength and its relation to exercise habits in Japanese. We used data from 3,018 men and 6,881 women aged 20–69 years and not using medications in a cross-sectional study. Exercise habits and muscle strength, *i.e.* grip strength and leg strength, were measured. Age-related changes in muscle strength were noted. Exercise habits were found in 984 men (32.6%) and 1,664 women (24.2%). For subjects of both sexes over 50 years, grip strength was significantly decreased with age. However, the ratio of leg strength to body weight significantly decreased with age as early as 30 years in men and 40 years in women. Grip strength, leg strength and the ratio of leg strength to body weight in subjects with exercise habits were significantly higher than those without exercise habits after adjusting for age in both sexes. This standard mean value may provide a useful database for evaluating muscle strength in Japanese adult subjects.

Key words: exercise habits, grip strength, leg strength

Exercise is a critical measure in the prevention of lifestyle-related diseases and improvement of their symptoms. The prevalence of subjects with exercise habits in Japan was reported to be 30.2% in men and 28.1% in women by the National Nutrition Survey in Japan (http://www.mhlw.go.jp/houdou/2008/04/dl/h0430-2g.pdf accessed on July 22, 2008); this report recommended an increase to 39% in men and 35% in women with exercise habits by 2010.

It is also well known that low and declining muscle strength is associated with increased mortality, independent of physical activity and muscle mass [1]. 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 (http://www.mhlw.go.jp/shingi/2006/07/dl/s0719-3b.pdf. accessed on July 1, 2007). Although resistance training has been advocated as the most suitable exercise for increasing muscle strength [2, 3], the link between exercise habits and muscle strength in a large sample of Japanese has not yet been investigated.

We evaluated muscle strength in Japanese subjects and compared results in those with and without exercise habits.

Subjects and Methods

Subjects. We used data of 3,018 men (38.8 ± 11.9 years) and 6,881 women (39.3 ± 12.6 years), aged

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20–69 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 March 2007 at Okayama Southern Institute of Health, 2) they had muscle strength and exercise habits evaluated as part of their annual health check-up, and 3) they were not taking any medications. In addition, 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.

Table 1 Number of subjects as classified by age group

Age	Men	Women
20–29	817	2,046
30–39	906	1,678
40–49	651	1,495
50–59	445	1,147
60–69	199	515
Total	3,018	6,881

Muscle strength. To assess muscle strength, grip and leg strength were measured [4]. 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. A dynamometer was then attached to the subject's one ankle joint by a strap. The subject extended his or her leg to 60 degrees as described in previous reports [4, 5] which have also demonstrated good accuracy for this measurement [5]. All muscle strength measurements were recorded in 2 trials, and the better one was employed for analysis. In addition, to standardize the influence of body weight, we calculated the ratio of leg strength to body weight; a ratio of 1.0 in leg strength per body weight has been a standard in past studies [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 a 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.

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; comparisons among more than three groups were performed by ANOVA and Scheffe's F test. $P<0.05$ was considered to indicate statistical significance.

Results

Muscle strength as classified by age group is summarized in Table 2. In men, right and left grip strengths were significantly decreased with age in subjects over 50 years. Leg strength was significantly decreased with age in subjects over 40 and the ratio of leg strength to body weight was significantly decreased with age in subjects over 30. In women, right grip strength, left grip strength and leg strength were significantly decreased with age in subjects over 50. The ratio of leg strength to body weight was significantly decreased with age in women subjects over 40.

The prevalence of subjects with exercise habits is summarized in Table 3. A total of 984 men (32.6%) and 1,664 women (24.2%) reported having exercise habits. The prevalence of subjects with exercise habits gradually increased with age, and the prevalence of exercise habits was highest for subjects in their 60's in both sexes (men, 49.2%; women, 50.1%).

We compared muscle strength in Japanese subjects with and without exercise habits. Right grip strength and left grip strength in subjects with exercise habits were similar to those in subjects without exercise habits in both sexes. Leg strength in both sexes and the ratio of leg strength to body weight in men were significantly higher for subjects with exercise habits than for those without exercise habit. However, the age of subjects with exercise habits was significantly higher than that of subjects without exercise habits. Therefore, we used age as a covariate and compared the muscle strength between Japanese with and without exercise habits using covariance analysis. All parameters of muscle strength were significantly higher in subjects with exercise habits than in those without such habits, after adjusting for age in both sexes.

We also compared muscle strength between sub-

Table 2 Muscle strength as classified by age group

	Men				Women			
	Mean ± SD	Minimum	Maximum	Median	Mean ± SD	Minimum	Maximum	Median
Grip strengh (right) (kg)								
20–29	46.8 ± 7.6	11.7	74.1	46.5	26.8 ± 5.2	10.3	77.6	26.7
30–39	46.6 ± 7.3	22.7	73.3	46.1	27.4 ± 4.9[a]	4.7	46.4	27.3
40–49	46.0 ± 7.5	9.8	71.6	45.4	27.7 ± 5.1[a]	6.1	52.2	27.6
50–59	42.9 ± 7.2[abc]	13.6	65.2	42.8	24.5 ± 4.8[abc]	5.3	38.6	24.5
60–69	38.2 ± 6.5[abcd]	8.7	53.7	38.7	23.0 ± 4.6[abcd]	11.8	39.9	22.8
Total	45.3 ± 7.8	8.7	74.1	45.1	26.4 ± 5.2	4.7	77.6	26.4
Grip strength (left) (kg)								
20–29	44.2 ± 7.4	11.9	68.9	43.5	25.3 ± 4.7	8.4	45.2	25.0
30–39	44.4 ± 7.1	15.4	71.3	44.2	26.1 ± 4.8[a]	8.8	44.0	25.9
40–49	44.0 ± 7.1	20.5	69.3	43.6	26.4 ± 4.8[a]	4.0	48.5	26.5
50–59	41.0 ± 6.6[abc]	14.5	59.4	41.4	23.6 ± 4.6[abc]	3.3	39.4	23.4
60–69	36.7 ± 6.4[abcd]	17.5	55.7	36.8	22.0 ± 4.3[abcd]	11.0	38.9	21.7
Total	43.1 ± 7.4	11.9	71.3	43.0	25.2 ± 4.9	3.3	48.5	25.1
Leg strength (kg)								
20–29	72.3 ± 16.7	32.1	152.0	71.0	43.3 ± 9.9	9.0	93.9	42.6
30–39	71.4 ± 16.9	31.0	161.4	69.4	43.4 ± 9.8	13.5	85.9	42.7
40–49	68.4 ± 15.5[ab]	27.0	124.4	67.3	43.4 ± 9.7	10.5	82.2	43.0
50–59	61.9 ± 14.4[abc]	27.2	109.6	62.4	40.1 ± 9.1[abc]	10.1	79.8	39.9
60–69	54.9 ± 12.5[abcd]	26.3	92.0	54.0	36.6 ± 8.3[abcd]	11.0	65.2	36.1
Total	68.1 ± 16.8	26.3	161.4	67.1	42.3 ± 9.8	9.0	93.9	41.8
Leg strength per body weight								
20–29	1.05 ± 0.22	0.48	1.80	1.04	0.83 ± 0.17	0.21	1.59	0.82
30–39	1.00 ± 0.22[a]	0.50	1.75	0.99	0.81 ± 0.18	0.28	1.55	0.80
40–49	0.96 ± 0.20[ab]	0.41	1.67	0.96	0.77 ± 0.17[ab]	0.23	1.60	0.77
50–59	0.90 ± 0.19[abc]	0.34	1.58	0.89	0.72 ± 0.16[abc]	0.23	1.45	0.71
60–69	0.84 ± 0.19[abcd]	0.42	1.49	0.83	0.68 ± 0.16[abcd]	0.21	1.23	0.67
Total	0.98 ± 0.22	0.34	1.80	0.97	0.78 ± 0.18	0.21	1.60	0.77

[a]$p<0.05$ vs age 20–29, [b]$p<0.05$ vs age 30–39, [c]$p<0.05$ vs age 40–49, [d]$p<0.05$ vs age 50–59.

Table 3 Prevalence of subjects with exercise habits in Japanese

	Exercise habits (+)		Exercise habits (−)	
Age	Number of subjects	%	Number of subjects	%
Men				
20–29	240	29.4	577	70.6
30–39	254	28.0	652	72.0
40–49	235	36.1	416	63.9
50–59	157	35.3	288	64.7
60–69	98	49.2	101	50.8
Total	984	32.6	2,034	67.4
Women				
20–29	341	16.7	1,705	83.3
30–39	297	17.7	1,381	82.3
40–49	373	25.0	1,122	75.1
50–59	395	34.4	752	65.6
60–69	258	50.1	257	49.9
Total	1,664	24.2	5,217	75.8

jects with and without exercise habits as classified by age group (Table 4). In men, right grip strength under the age of 50, left grip strength in 20's, leg strength under the age of 40 and the ratio of leg strength to body weight under the age of 50 were significantly higher in subjects with exercise habits than in those without. In women, right grip strength under the age of 40, left grip strength in 20's, 30's and 50's, leg strength in 20's, 30's and 50's, and the ratio of leg strength to body weight in 20's, 30's and 50's were significantly higher in subjects with exercise habits than in those without.

Discussion

In this study, we explored muscle strength and its

Table 4 Comparison of muscle strength between Japanese with and without exercise habits as classified by age group

	Men			Women		
Age	Exercise habits (+)	Exercise habits (−)	*p*	Exercise habits (+)	Exercise habits (−)	*p*
Grip strength (right) (kg)						
20–29	47.9 ± 7.9	46.3 ± 7.4	**0.0082**	27.8 ± 5.2	26.6 ± 5.2	**0.0003**
30–39	47.5 ± 7.4	46.3 ± 7.2	**0.0300**	28.1 ± 5.1	27.3 ± 4.9	**0.0094**
40–49	46.9 ± 7.3	45.4 ± 7.5	**0.0156**	28.1 ± 5.3	27.5 ± 5.0	0.0590
50–59	43.4 ± 7.2	42.7 ± 7.3	0.4444	24.9 ± 4.9	24.3 ± 4.7	0.0602
60–69	37.8 ± 6.4	38.6 ± 6.6	0.3840	23.0 ± 4.7	23.0 ± 4.5	0.9198
Grip strength (left) (kg)						
20–29	45.2 ± 7.1	43.8 ± 7.4	**0.0146**	25.9 ± 4.9	25.1 ± 4.6	**0.0103**
30–39	45.1 ± 7.5	44.1 ± 6.9	0.0520	26.8 ± 5.0	26.0 ± 4.7	**0.0065**
40–49	44.6 ± 6.8	43.6 ± 7.2	0.0833	26.7 ± 5.2	26.3 ± 4.7	0.1737
50–59	41.5 ± 7.0	40.8 ± 6.3	0.2822	24.0 ± 4.6	23.4 ± 4.5	**0.0459**
60–69	36.6 ± 6.2	36.8 ± 6.7	0.8076	21.9 ± 4.4	22.1 ± 4.1	0.7156
Leg strength (kg)						
20–29	75.4 ± 16.8	70.9 ± 16.4	**0.0004**	45.9 ± 10.3	42.8 ± 9.7	**<0.0001**
30–39	73.5 ± 17.4	70.5 ± 16.6	**0.0155**	45.0 ± 9.8	43.1 ± 9.8	**0.0033**
40–49	69.2 ± 15.4	67.9 ± 15.5	0.3057	44.0 ± 9.8	43.2 ± 9.7	0.1479
50–59	63.4 ± 14.4	61.1 ± 14.4	0.1101	40.9 ± 9.8	39.7 ± 8.7	**0.0397**
60–69	55.0 ± 11.3	54.8 ± 13.6	0.9202	37.0 ± 8.0	36.2 ± 8.6	0.3203
Leg strength per body weight						
20–29	1.09 ± 0.22	1.03 ± 0.22	**0.0006**	0.87 ± 0.18	0.82 ± 0.17	**<0.0001**
30–39	1.04 ± 0.24	0.99 ± 0.21	**0.0013**	0.85 ± 0.19	0.81 ± 0.18	**0.0007**
40–49	0.99 ± 0.20	0.95 ± 0.20	**0.0206**	0.79 ± 0.17	0.77 ± 0.17	0.0765
50–59	0.92 ± 0.20	0.89 ± 0.14	0.0658	0.74 ± 0.17	0.71 ± 0.15	**0.0031**
60–69	0.85 ± 0.20	0.82 ± 0.17	0.2406	0.68 ± 0.16	0.67 ± 0.16	0.3496

Mean ± SD

relation to exercise habits in Japanese. This information gathered should serve as a quite useful database for evaluating muscle strength in Japanese subjects.

The prevalence of subjects with exercise habit in Japan was reported to be 30.2% of men and 28.1% of women by the National Nutrition Survey in Japan. The definition of duration (3 months) in our study was shorter than in the survey definition, and we eliminated subjects who took medications. The subjects enrolled in our study undertook annual health check-ups and they might therefore be more careful of their own health than subjects in the National Nutrition Survey. However, our results by analysis of subjects without medications were comparable to those in the survey. The prevalence of exercise habits in subjects with medications is higher than that in subjects without medications in both sexes (data not shown).

It has been well reported that there is significant loss in muscle strength with aging [6, 7]. Aging is associated with alterations in body composition; there is an increase in body fat percentage and a concomitant decline in lean body mass [8]. Aging, therefore, results in substantial alterations in body composition, with a marked reduction in skeletal muscle mass. Loss of muscle strength may be an important cause of the age-related loss in bone strength resulting in osteoporosis and can also influence the ability to perform simple tasks such as sitting on a chair or visiting the toilet [9]. In frail, institutionalized men and women, muscle strength is a determinant factor for exercise capacity; *e.g.* it is highly related to habitual walking speed. Especially, leg strength is closely related to the speed of walking up stairs, the speed of standing up from a chair, and gait speed. We have previously reported that the ratio of leg strength to body weight in subjects with metabolic syndrome was significantly lower than that in subjects without the syndrome [4] and that increasing the ratio of leg strength to body

weight is important in subjects with metabolic syndrome.

In this study, age-related loss of muscle strength was noted as in previous studies using a large sample of subjects not taking any medications. Grip strength was significantly decreased with age in subjects of both sexes over the age of 50. However, the ratio of leg strength to body weight was significantly decreased with age in male subjects over 30 and female subjects over 40. Age-related changes in the ratio of leg strength to body weight were noted in young adults. It seems difficult for subjects with a low ratio of leg strength to body weight to support their entire body's weight; it also seems difficult for such subjects to perform aerobic exercise *e.g.* walking and jogging.

Although muscle strength in subjects with exercise habits was significantly higher than that in subjects without exercise habits after adjusting for age, no significant differences in muscle measurements were noted over the age of 60. According to the National Nutrition Survey in Japan, the prevalence of subjects with exercise habits increases with age, while daily step counts decrease with age (http://www.mhlw.go.jp/houdou/2008/04/dl/h0430-2g.pdf accessed on Jan 20, 2009). Lower exercise intensity and shorter exercise time in elderly adults as well as the small sample size may make it difficult to infer causality between exercise habits and muscle strength in this group. However, lower and declining muscle strength has been associated with increased mortality, independent of physical activity and muscle mass [1]. Tammelin *et al.* reported that men having a heavy physical work score had higher grip strength [10]. Fujita *et al.* also reported that activity of daily living was closely linked to grip strength in community-dwelling elderly after hip fracture [11]. Taken together, it seems reasonable to suggest that simply improving muscle strength by promoting exercise habits might result in decreased mortality in some Japanese.

Further prospective investigation studies to evaluate the relationship between exercise habits and muscle strength are needed in Japanese.

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References

1. Metter EJ, Talbot LA, Schrager M and Conwit R: Skeletal muscle strength as a predictor of all-cause mortality in healthy men. J Gerontol A Biol Sci Med Sci (20002) 57: B359–B365.
2. Rhodes EC, Martin AD, Taunton JE, Donnelly M, Warren J and Elliot J: Effect of one year of resistance training on the relation between musclar strength and bone density in elderly women. Br J Sports Med (2000) 34: 18–22.
3. Geliebter A, Mahaer MM, Gerace L, Gutin B, Heymsfield SB and 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: 557–563.
4. Miyatake N, Wada J, Nishikawa H, Saito T, Takenami S, Miyachi M, Makino H and Numata T: Comparison of muscle strength between Japanese men with and without metabolic syndrome. Acta Med Okayama (2007) 66: 99–102.
5. Kigawa A, Yamamoto T, Koyama Y, Kageyama S and Arima K: Evaluation of knee extensor strength for prevention of sports injury. Japan Ortho Soc Sports Med (1987) 6: 141–145 (in Japanese).
6. Larsson L and Karlsson J: Isometric and dynamic endurance as a function of age and skeletal muscle characteristics. Acta Physiol Scand (1978) 104: 129–136.
7. Young A, Stokes M and Crowe M: Size and strength of the quadriceps muscles of old and young women. Eur J Clin Invest (1984) 14: 282–287.
8. Rogers MA and Evans WJ: Changes in skeletal muscle with aging: effects of exercise training. Exerc Sports Sci Rev (1993) 21: 65–102.
9. Rantanen T, Guralnik JM, Sakari-Rantala R, Leveille S, Simonsick EM, Ling S and Fried LP: Disability, physical activity, and muscle strength in older women: the Women's Health Aging Study. Arch Phys Med Rehabil (1999) 80: 130–135.
10. Tammelin T, Nayha S, Rintamaki H and Zitting P: Occupational physical activity is related to physical fitness in young workers. Med Sci Sports Exerc (2002) 34: 158–165.
11. Fujita H, Shiomi T, Arahata K and Ishibashi H: Relationship between activity of daily living and motor function in the community-dwelling elderly after hip fracture. Nippon Ronen Igakkai Zasshi (2006) 43: 241–245.