Vol.4, No.1, 1-5 (2012)
doi:10.4236/health.2012.41001

Relationship between muscle strength and anthropometric, body composition parameters in Japanese adolescents

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Received 8 November 2011; revised 29 November 2011; accepted 8 December 2011.

ABSTRACT

We investigated the link between muscle strength and anthropometric, body composition parameters in Japanese adolescents. Forty eight men and 189 women, aged 15 - 19 years, were enrolled in this cross-sectional investigation study. Anthropometric and body composition parameters *i.e.* height, body weight, abdominal circumference, hip circumference and body fat percentage were measured. Muscle strength *i.e.* grip strength and leg strength were also evaluated. In men, grip strength was positively correlated with height and lean body mass. Leg strength was significantly correlated with height, body weight, hip circumference and lean body mass (r = 0.708). However, leg strength per body weight was negatively correlated with body mass index (BMI), abdominal circumference, hip circumference, body fat percentage (r = –0.719) and body fat mass. In women, grip strength was positively correlated with height. Leg strength was positively correlated with lean body mass (r = 0.482). Leg strength per body weight was negatively correlated with body fat percentage (r = –0.457) and body fat mass. Grip and leg strength was positively correlated with height and lean body mass, especially in men. However, leg strength per body weight was closely linked to body fat percentage in both sexes.

Keywords: Anthropometric Parameters; Body Composition; Grip Strength; Leg Strength; Leg Strength Per Body Weight

1. INTRODUCTION

It is also well known that low and declining muscle strength is associated with increased mortality, independent of physical activity and muscle mass [1]. It has been well reported that there is significant loss in muscle strength with aging [2,3]. Aging is associated with alterations in body composition; there is an increase in body fat percentage and a concomitant decline in lean body mass [4]. 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 [5]. We have previously evaluated muscle strength, aged 20 - 79 years, and found that age-related changes in muscle strength were noted. In addition, lower leg strength per body weight was fundamental feature in subjects with obesity [6]. In this respect, it is important to evaluate muscle strength of adolescents for preventing future decline in muscle strength in adults. However, the relation between muscle strength, especially leg strength and anthropometric, body composition parameters still remains to be investigated.

In this study, we evaluated muscle strength *i.e.* grip strength and leg strength and its relation to anthropometric, body composition parameters in Japanese adolescents.

2. SUBJECTS AND METHODS

2.1. Subjects

We used data for 48 men and 189 women, aged 15 - 19 years, who met the following criteria: 1) received a health check-up including health guidance, 2) received anthropometric and body composition measurements, and muscle strength 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**).

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

2.2. Anthropometric and Body Composition Measurements

Their anthropometric and body composition were evaluated by using the following respective parameters such as, height, body weight, body mass index (BMI), abdominal circumference, hip circumference and body fat percentage. BMI was calculated by weight/[height]^2 (kg/m^2). Abdominal circumference was measured at the umbilical level in standing subjects after normal expiration [7] and the hip was measured at the widest circumferences over the trochanter in standing subjects after normal expiration. Body fat percentage was measured by an air displacement plethysmograph called the BOD POD Body Composition System (Life Measurement Instruments, Concord, CA) [8,9]. Body fat mass was calculated as follows: body weight × body fat percentage × 100. Lean body mass was also calculated as follows: body weight—body fat mass.

2.3. Muscle Strength

To assess muscle strength, grip and leg strength were measured [6,10]. 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 [6,10,11] which have also demonstrated good accuracy for this measurement [11]. 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 1.0 in leg strength per body weight has been a standard in past studies [11].

2.4. Statistical Analysis

Data are expressed as means ± standard deviation (SD). Pearson's correlation coefficients were calculated and used to test the significance of the linear relationship among continuous variables; stepwise multiple regression analysis was also used.

3. RESULTS

Clinical profiles of enrolled subjects are summarized in **Table 1**. In addition, we evaluated the relationship between anthropometric, body composition parameters and muscle strength (**Table 2**). In men, grip strength was positively correlated with height and lean body mass. Leg strength was significantly correlated with height, body weight, hip circumference and lean body mass (r = 0.708, $p < 0.0001$) (**Figure 1**). However, leg strength per body weight was negatively correlated with BMI, abdominal circumference, hip circumference, body fat percentage (r = –0.719, $p < 0.0001$) (**Figure 2**) and body fat mass (r = –0.623, $p < 0.0001$). In women, grip strength

Table 1. Clinical profiles of enrolled subjects.

	Men			Women		
	Mean ± SD	Minimum	Maximum	Mean ± SD	Minimum	Maximum
Number of subjects	48			189		
Age	17.8 ± 1.2	15	19	18.4 ± 1.0	15	19
Height (cm)	170.3 ± 6.2	154.6	181.6	157.8 ± 5.5	135.1	175.5
Body weight (kg)	67.7 ± 15.3	42.1	118.7	54.3 ± 9.3	35.9	96.2
Body mass index (kg/m^2)	23.2 ± 4.6	17.6	39.8	21.8 ± 3.7	16.2	37.6
Abdominal circumference (cm)	76.9 ± 12.8	58.5	122.2	67.2 ± 7.6	54.5	106.4
Hip circumference	93.5 ± 8.2	77.2	116.6	91.7 ± 6.6	77.0	125.0
Body fat percentage (%)	18.0 ± 7.8	8.7	39.0	27.1 ± 6.0	12.4	46.1
Body fat mass (kg)	13.0 ± 9.1	4.8	46.3	15.1 ± 5.9	5.3	41.3
Lean body mass (kg)	54.7 ± 8.3	32.8	72.4	39.2 ± 4.7	29.4	56.0
Right grip strength (kg)	42.8 ± 8.3	16.2	60.0	26.7 ± 5.2	9.3	41.1
Left grip strength (kg)	40.7 ± 9.0	14.3	61.4	24.9 ± 4.5	8.9	37.5
Leg strength (kg)	69.4 ± 15.1	26.8	91.5	46.9 ± 10.1	15.8	82.0
Leg strength per body weight	1.04 ± 0.22	0.58	1.44	0.87 ± 0.18	0.38	1.42

Table 2. Relationship between muscle strength and anthropometric, body composition parameters.

	Right grip strength (kg)		Left grip strength (kg)		Leg strength (kg)		Legs strength per body weight	
	r	*p*	r	*p*	r	*p*	r	*p*
					Men			
Height (cm)	0.417	**0.0032**	0.481	**0.0005**	0.534	**<0.0001**	0.065	0.6584
Body weight (kg)	0.203	0.1662	0.208	0.1554	0.459	**0.0010**	−0.394	**0.0056**
Body mass index (kg/m^2)	0.112	0.4476	0.090	0.5412	0.352	**0.0140**	−0.456	**0.0011**
Abdominal circumference (cm)	0.057	0.6984	0.030	0.8375	0.281	0.0534	−0.510	**0.0002**
Hip circumference (cm)	0.199	0.1750	0.157	0.2855	0.434	**0.0021**	−0.456	**0.0042**
Body fat percentage (%)	−0.264	0.0693	−0.324	0.0248	−0.081	0.5844	−0.719	**<0.0001**
Body fat mass (kg)	−0.094	0.5238	−0.109	0.4620	0.128	0.3876	−0.623	**<0.0001**
Lean body mass (kg)	0.478	**0.0006**	0.503	**0.0003**	0.708	**<0.0001**	−0.046	0.7538
					Women			
Height (cm)	0.404	**<0.0001**	0.430	**<0.0001**	0.236	**0.0011**	0.022	0.7673
Body weight (kg)	0.102	0.1638	0.130	0.0736	0.368	**<0.0001**	−0.341	**<0.0001**
Body mass index (kg/m^2)	−0.073	0.3197	−0.052	0.4769	0.279	**<0.0001**	−0.360	**<0.0001**
Abdominal circumference (cm)	−0.097	0.1830	−0.074	0.3097	0.247	**0.0006**	−0.370	**<0.0001**
Hip circumference (cm)	0.077	0.2906	0.086	0.2406	0.319	**<0.0001**	−0.347	**<0.0001**
Body fat percentage (%)	−0.192	**0.0083**	−0.174	0.0164	0.042	0.5646	−0.457	**<0.0001**
Body fat mass (kg)	−0.077	0.2945	−0.054	0.4641	0.198	**0.0064**	−0.431	**<0.0001**
Lean body mass (kg)	0.300	**<0.0001**	0.328	**<0.0001**	0.482	**<0.0001**	−0.134	0.0662

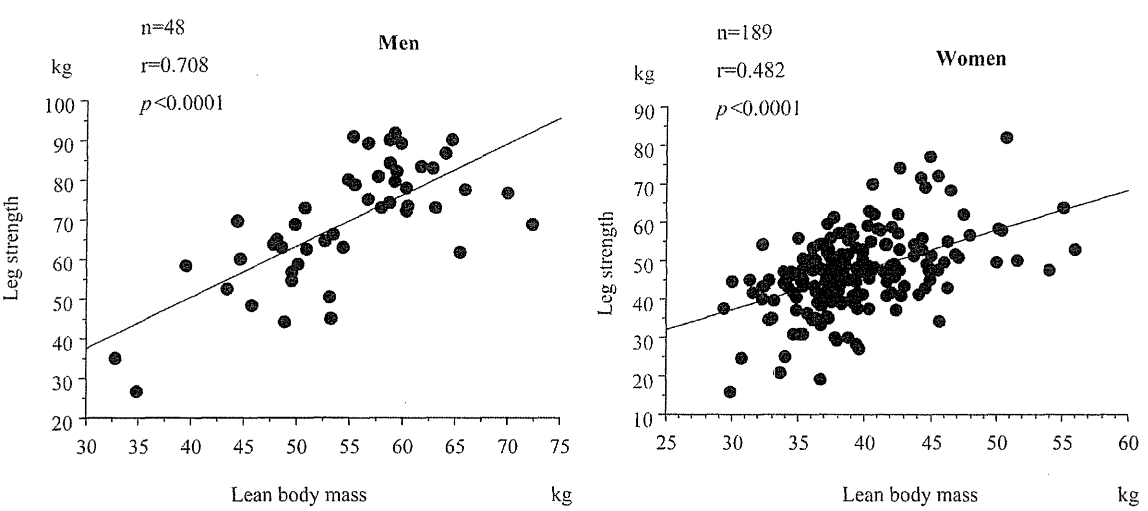

Figure 1. Simple correlation analysis between leg strength and lean body mass.

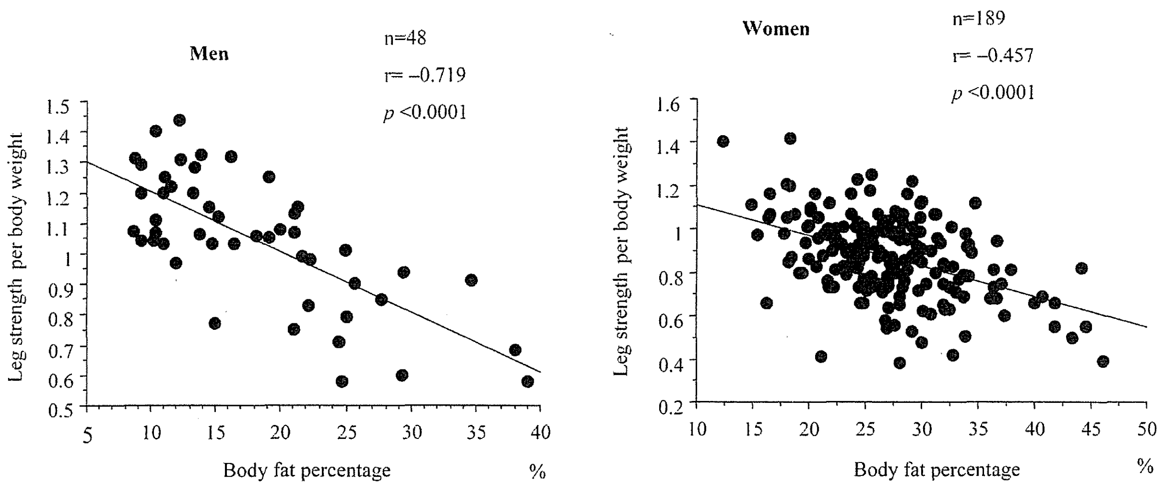

Figure 2. Simple correlation analysis between leg strength per body weight and body fat percentage.

was positively correlated with height. Leg strength was positively correlated lean body mass (r = 0.482, $p < 0.0001$) (**Figure 1**). Leg strength per body weight was negatively correlated with body fat percentage (r = –0.457, $p < 0.0001$) (**Figure 2**) and body fat mass (r = –0.431, $p < 0.0001$).

We also used stepwise multiple regression analysis to evaluate the effect of clinical parameters *i.e.* age, height, body weight, BMI, abdominal circumference, hip circumference, body fat percentage, body fat mass and lean body mass on leg strength per body weight, and found that age and body fat percentage were significant in men (leg strength per body weight = 0.750 + 0.036 (age) – 0.020 (body fat percentage), $r^2 = 0.557$, $p < 0.0001$) and only body fat percentage was significant in women (leg strength per body weight = 1.255 – 0.014 (body fat percentage), $r^2 = 0.208$, $p < 0.0001$).

4. DISCUSSION

The main finding of this study was that we explored that the relation between muscle strength and anthropometric, body composition parameters, and found that height and lean body mass were closely correlated with grip and leg strength, especially in men. However, leg strength per body weight was negatively correlated with body fat percentage in both sexes.

Jurimae *et al.* have reported that the most important predictive value for grip strength from the basic anthropometric variables was body height, and skin fold thicknesses was not related to grip strength in prepubertal children aged between 8 and 11 years [12]. They also reported that hand lean mass highly influenced hand grip strength in boys, and moderately but significantly in girls [12]. Koley *et al.* showed that hand dominance, especially of the right hand, has some close association with the anthropometric variables related to upper extremities in 303 healthy students (height in men: r = 0.275, height in women: r = 0.200) [13]. Luna-Heredia *et al.* described that body height is directly correlated with hand grip strength, possibly because this factor is more closely related to the lean body mass [14].

In this study, we also found that height and lean body mass were important factors for grip and leg strength, especially men. However, leg strength per body weight was negatively correlated with body fat percentage. Taken together, it is difficult for Japanese adolescents with lower leg strength per body weight to support the entire body's weight; and also difficult for subjects with lower leg strength per body weight to carry out aerobic exercise *i.e.* walking and jogging. In addition, we have previously reported that changes in oxygen uptake at VT (per lean body mass) were also correlated with changes in leg strength per lean body mass in adults [15,16]. Although aerobic exercise has been advocated as most suitable for reducing fat mass and increasing aerobic exercise level, it is important for subjects with lower leg strength per body weight to maintain or maximize the muscle strength of their lower limbs as well as to carry out aerobic exercise for reducing fat mass and increasing aerobic exercise level in Japanese adolescents.

Potential limitations still remain in this study. First, our study was a cross-sectional and not a longitudinal study. Second, 48 men and 189 women in our study voluntarily underwent measurements: they were therefore more likely to be health-conscious compared with the average person. To show this, further prospective studies are needed to prove the link in the Japanese adolescents.

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] Metter, E.J., Talbot, L.A., Schrager, M. and Conwit R. (2002) Skeletal muscle strength as a predictor of all-cause mortality in healthy men. *The Journals of Gerontology: Series A*, **57**, B359-B365.

[2] Larsson, L. and Karlsson, J. (1978) Isometric and dynamic endurance as a function of age and skeletal muscle characteristics. *Acta Physiologica Scandinavica*, **104**, 129-136. doi:10.1111/j.1748-1716.1978.tb06259.x

[3] Young, A., Stokes, M. and Crowe, M. (1984) Size and strength of the quadriceps muscles of old and young women. *European Journal of Clinical Investigation*, **14**, 282-287. doi:10.1111/j.1365-2362.1984.tb01182.x

[4] Rogers, M.A. and Evans, W.J. (1993) Changes in skeletal muscle with aging: Effects of exercise training. *Exercise and Sport Sciences Reviews*, **21**, 65-102. doi:10.1249/00003677-199301000-00003

[5] Rantanen, T., Guralnik, J.M., Sakari-Rantala, R., Leveille, S., Simonsick, E.M., Ling, S. and Fried, L.P. (1999) Disability, physical activity, and muscle strength in older women: The women's health aging study. *Archives of Physical Medicine and Rehabilitation*, **80**, 130-135. doi:10.1016/S0003-9993(99)90109-0

[6] Miyatake, N., Fujii, M., Nishikawa, H., Wada, J., Shikata, K., Makino, H. and Kimura, I. (2000) Clinical evaluation of muscle strength in 20-79-years-old obese Japanese. *Diabetes Research and Clinical Practice*, **48**, 15-21. doi:10.1016/S0168-8227(99)00132-1

[7] (2005) Definition and the diagnostic standard for metabolic syndrome—Committee to Evaluate Diagnostic Standards for Metabolic Syndrome. In Japanese. *Nippon Naika Gakkai Zasshi*, **94**, 794-809. doi:10.2169/naika.94.794

[8] Miyatake, N., Nonaka, K. and Fujii M. (1999) A new air displacement plethysmograph for the determination of Japanese body composition. *Diabetes, Obesity and Metabolism*, **1**, 347-351. doi:10.1046/j.1463-1326.1999.00064.x

[9] Mccrory, M.A., Gomez, T.D., Bernauer, E.M. and Mole, P.A. (1995) Evaluation of a new air displacement plethysmograph for measuring human body composition. *Medicine & Science in Sports & Exercise*, **27**, 1686-1691. doi:10.1249/00005768-199512000-00016

[10] Miyatake, N., Wada, J., Nishikawa, H., Saito, T., Takenami, S., Miyachi, M., Makino, H. and Numata, T. (2007) Comparison of muscle strength between Japanese men with and without metabolic syndrome. *Acta Med Okayama*, **66**, 99-102.

[11] Kigawa, A., Yamamoto, T., Koyama, Y., Kageyama, S. and Arima, K. (1987) Evaluation of knee extensor strength for prevention of sports injury. In Japanese, *Japanese Orthopaedic Society of Sports Medicine*, **6**, 141-145.

[12] Jurimae, T., Hurbo, T. and Jurimae, J. (2009) Relationship of handgrip strength with anthropometric and body composition variables in prepubertal children. *Homo*, **60**, 225-238. doi:10.1016/j.jchb.2008.05.004

[13] Koley, S. and Singh, A.P. (2009) An association of dominant hand grip strength with some anthropometric variables in Indian collegiate population. *Anthropologischer Anzeiger*, **67**, 21-28. doi:10.1127/0003-5548/2009/0003

[14] Luna-Heredia, E., Martin-Pena, G. and Ruiz-Galiana, J. (2005) Handgrip dynamometer in healthy adults. *Clinical Nutrition*, **24**, 250-258. doi:10.1016/j.clnu.2004.10.007

[15] Miyatake, N., Miyachi, M., Tabata, I. and Numata, T. (2009) Leg strength per body weight is associated with ventilatory threshold in Japanese women. *Anti-Aging Medicine*, **6**, 5-9.

[16] Miyatake, N., Takenami, S., Kawasaki, Y. and Fujii, M. (2004) Relationship between visceral fat accumulation and physical fitness in Japanese women. *Diabetes Research and Clinical Practice*, **64**, 173-179. doi:10.1016/j.diabres.2003.11.004

Open Journal of Epidemiology, 2012, 2, 22-27
doi:10.4236/ojepi.2012.21004 Published Online February 2012 (http://www.SciRP.org/journal/ojepi/)

Evaluation of whole body reaction time and one leg with eye closed balance in elderly Japanese*

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Received 28 November 2011; revised 19 January 2012; accepted 27 January 2012

ABSTRACT

We evaluated whole body reaction time and one leg with eye closed balance in elderly Japanese. A total of 2059 elderly Japanese (730 men and 1329 women), aged 60 - 79 years, were enrolled in the cross-sectional investigation study. Anthropometric parameters, whole body reaction time and one leg with eye closed balance were measured. Whole body reaction time was significantly higher and one leg with eye closed balance was significantly lower in 70's than those in 60's in both sexes. Two hundred twenty seven men (31.1%) and 533 women (40.1%) were having no medications. In men, whole body reaction time was significantly higher and one leg with eye closed balance was significantly lower in subjects with medications than those in subjects without in 60's. However, significant differences of whole body reaction time and one leg with eye closed balance between subjects with and without medications in men with 70's and women with 60's and 70's were not noted. This standard mean value may provide a useful reference database for evaluating whole body reaction time and one leg with eye closed balance in Japanese elderly subjects.

Keywords: Elderly Japanese; Whole Body Reaction Time; One Leg with Eye Closed Balance

1. INTRODUCTION

Rate of elderly subjects (over 65 years) in Japan are dramatically increased and has become public health challenge in Japan. For example, 28,216,000 subjects (22.1%) are reported to be over 65 years old in Japan [1].

It has been shown that obese subjects have a high mortality rate [2] and have linked to atherogenic risk factors, such as hypertension, coronary heart disease, diabetes mellitus and dyslipidemia [3]. In addition, physical fitness was a graded, independent, long-term predictor of mortality from cardiovascular causes in healthy, middle-aged men [4]. Lower and declining muscle strength was also associated with increased mortality, independent of physical activity and muscle mass [5]. We have previously showed that anthropometric parameters, muscle strength, flexibility and aerobic exercise level in elderly Japanese. Especially in elderly subjects without medications, this standard mean value in 60's and 70's may provide a useful database for evaluating anthropometric parameters and physical fitness [6]. However, according to other physical fitness *i.e.* agility and balance, there are few studies that focused on reductions in mortality or the prevention of lifestyle-related diseases, and the optimal level was not defined. Therefore, evaluation of agility *i.e.* whole body reaction time and balance *i.e.* one leg with eye closed balance still remains to be investigated in elderly Japanese without medications.

In this study, we evaluated whole body reaction time and one leg with eye closed balance in elderly Japanese and compared those parameters between subjects with and without medications.

2. SUBJECTS AND METHODS

2.1. Subjects

A total of 2059 elderly subjects (730 men and 1,329 women), aged 60 - 79 years, was enrolled in this cross-sectional investigation study. All subjects met the following criteria: 1) they had been wanting to change their lifestyle *i.e.*, diet and exercise habits, and had received an annual health checkup from June 1997 to Dec 2009 at Okayama Southern Institute of Health; 2) their anthropometric, whole body reaction time and one leg with eye closed balance measurements had been taken as part of their annual health checkups; and 3) they provided written informed consent (**Table 1**).

The study was approved by the Ethics Committee of Okayama Health Foundation.

*There is no conflict of interest.

Table 1. Clinical profiles of enrolled subjects.

	Men (n = 730)			Women (n = 1329)		
	Mean ± SD	Minimum	Maximum	Mean ± SD	Minimum	Maximum
Age	65.6 ± 4.6	60	79	64.8 ± 4.1	60	79
Height (cm)	164.4 ± 5.5	145.3	180.2	151.9 ± 5.0	136.2	167.0
Body weight (kg)	65.9 ± 9.3	40.1	112.2	55.1 ± 7.6	33.4	92.4
Body mass index (kg/m^2)	24.3 ± 3.0	16.2	40.9	23.9 ± 3.1	15.4	41.9
Abdominal circumference (cm)	86.0 ± 9.2	61.6	127.0	78.7 ± 9.1	54.7	121.6
Hip circumference (cm)	91.9 ± 5.5	77.8	122.7	90.2 ± 5.2	69.0	120.5
Whole body reaction time (sec)	0.44 ± 0.10	0.24	1.01	0.46 ± 0.10	0.26	0.99
One leg with eye closed balance (sec)	9.6 ± 10.7	1.0	93.0	10.1 ± 12.0	1.0	120.0
Number of subjects without medications (%)	227 (31.1)			533 (40.1)		

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 [7].

2.3. Whole Body Reaction Time

Whole body reaction time was measured by using THP-15 (Sakai, Tokyo, Japan) (**Figure 1**) as follows. Subjects stood still with a posture to be able to change immediately and concentrated attention on a red lamp. When the subjects watch the lamp shined, they jumped as early as possible. Average second of five trials that both legs completely left from a floor was employed to be whole body reaction time [8].

2.4. One Leg with Eye Closed Balance

The examiner first asks the subjects to decide on which leg they would like to stand. The subjects are then asked to stand initially in a relaxed stance with their weight evenly distributed between both. With their eyes close, the subjects are instructed to stand on the leg they have selected, without using any assistive device, and keeping their arms by their sides. The test is over after 120s has elapsed, when the stance foot shifts, or when the lifted foot is replaced on the board, whichever occurs first. To prevent falls or injuries, the examiner stands close to the subjects throughout the trial (**Figure 2**) [9].

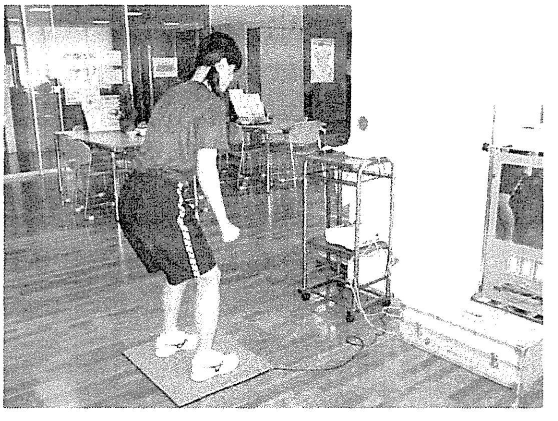

Figure 1. Measurements of whole body reaction time photographed at Okayama Southern Institute of Health, Okayama, Japan.

Figure 2. Measurements of one leg with eye closed balance photographed at Okayama Southern Institute of Health, Okayama, Japan.

2.5. Medications

The data on medications were obtained at interviews conducted by well-trained medical staff using the structured method. The subjects were asked if they currently take medications *i.e* diabetes, hypertension, dyslipidemia and/or orthopedic diseases. When the answer was "yes", they were classified as subjects with medications. When the answer was "no", they were classified as subjects without medications.

2.6. 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: $p < 0.05$ was considered to be statistically significant.

3. RESULTS

Clinical profiles are summarized in **Table 1**. Twenty hundred and twenty seven men (31.1%) and 533 women (40.1%) were take no medications.

We compared the clinical parameters between subjects 60's and 70's (**Table 2**). In men, height, body weight, BMI and hip circumference in 60's were significantly higher than those in 70's. However, abdominal circumference in 60's was similar to that in 70's. In women, height was significantly higher and abdominal circumference was significantly lower in 60's than those in 70's. Whole body reaction time was significantly lower and one leg with eye closed balance was significantly higher in 60's than those in 70's in both sexes.

We further analyzed clinical parameters between subjects with and without medications (**Table 3**). There were significant differences of anthropometric parameters (except height), whole body reaction time and one leg with eye closed balance between men with and without medications. In women, there were also significant differences of anthropometric parameters (except height and hip circumference), whole body reaction time and one leg with eye closed balance between subjects with and without medications.

In addition, in 60's, significant differences of whole body reaction time and one leg with eye closed balance between men with and without medications, and body weight, BMI, abdominal circumference and hip circumference between women with and without medications were noted. In 70's, anthropometric parameters were significantly higher in men with medications than those in men without medications. There were not significant differences of other parameters between subjects with and without medications (**Table 3**).

We found that there were significant differences of some parameters between subjects with and without medications. We finally compared parameters between 60's and 70's in subjects without medications (**Table 4**). In men, anthropometric parameters and one leg with eye closed balance were significantly lower and whole body reaction time was significantly higher in 70's than those in 60's. In women, whole body reaction time was significantly higher, height and one leg with eye closed balance were significantly lower in 70's than those in 60's. There were no differences of other parameters between 60's and 70's in subjects without medications.

Table 2. Comparison of clinical parameters in all subjects.

	Men			Women		
	60 - 69	70 - 79	*p*	60 - 69	70 - 79	*p*
Number of subjects	589	141		1140	189	
Height (cm)	164.8 ± 5.3	162.7 ± 5.9	**<0.0001**	152.2 ± 4.9	149.8 ± 5.0	**<0.0001**
Body weight (kg)	66.5 ± 9.0	63.3 ± 10.0	**0.0002**	55.2 ± 7.6	54.5 ± 7.6	0.2529
Body mass index (kg/m^2)	24.5 ± 3.0	23.8 ± 3.0	**0.0279**	23.8 ± 3.1	24.3 ± 3.2	0.0550
Abdominal circumference (cm)	86.1 ± 9.1	85.6 ± 9.6	0.5186	78.2 ± 8.9	81.7 ± 10.0	**<0.0001**
Hip circumference (cm)	92.2 ± 5.4	90.7 ± 5.6	**0.0040**	90.2 ± 5.2	89.9 ± 5.3	0.4198
Whole body reaction time (sec)	0.43 ± 0.09	0.49 ± 0.13	**<0.0001**	0.45 ± 0.09	0.52 ± 0.12	**<0.0001**
One leg with eye closed balance (sec)	10.6 ± 11.5	5.2 ± 4.6	**<0.0001**	10.9 ± 12.7	5.0 ± 4.3	**<0.0001**

Table 3. Comparison of clinical parameters between subjects with and without medications as classified by age groups.

	Men			Women		
	Medication (–)	Medication (+)	*p*	Medication (–)	Medication (+)	*p*
All subjects						
Number of subjects	227	503		533	796	
Height (cm)	164.2 ± 5.4	164.5 ± 5.5	0.3979	152.0 ± 5.2	151.8 ± 4.9	0.3890
Body weight (kg)	64.5 ± 8.7	66.5 ± 9.5	**0.0090**	54.3 ± 7.3	55.6 ± 7.8	**0.0015**
Body mass index (kg/m^2)	23.9 ± 2.7	24.5 ± 3.1	**0.0089**	23.5 ± 3.0	24.2 ± 3.2	**0.0002**
Abdominal circumference (cm)	84.6 ± 9.0	86.7 ± 9.2	**0.0057**	77.3 ± 8.7	79.6 ± 9.3	**<0.0001**
Hip circumference (cm)	91.2 ± 5.0	92.2 ± 5.6	**0.0279**	89.9 ± 5.0	90.4 ± 5.4	0.0781
Whole body reaction time (sec)	0.43 ± 0.10	0.45 ± 0.1	**0.0012**	0.45 ± 0.09	0.46 ± 0.10	**0.0016**
One leg with eye closed balance (sec)	12.0 ± 12.9	8.5 ± 9.4	**<0.0001**	11.2 ± 13.5	9.4 ± 10.9	**0.0072**
60 - 69						
Number of subjects	193	396		485	655	
Height (cm)	164.8 ± 5.0	164.9 ± 5.4	0.8700	152.2 ± 5.1	152.3 ± 4.8	0.8571
Body weight (kg)	65.7 ± 8.2	66.9 ± 9.4	0.1128	54.4 ± 7.4	55.8 ± 7.7	**0.0021**
Body mass index (kg/m^2)	24.2 ± 2.6	24.6 ± 3.1	0.0812	23.5 ± 3.0	24.1 ± 3.2	**0.0014**
Abdominal circumference (cm)	85.3 ± 8.8	86.5 ± 9.3	0.1439	77.1 ± 8.6	79.0 ± 9.0	**0.0004**
Hip circumference (cm)	91.7 ± 4.7	92.4 ± 5.7	0.1868	89.9 ± 5.0	90.5 ± 5.3	**0.0401**
Whole body reaction time (sec)	0.42 ± 0.08	0.44 ± 0.09	**0.0009**	0.44 ± 0.09	0.45 ± 0.09	0.0678
One leg with eye closed balance (sec)	13.0 ± 13.5	9.4 ± 10.1	**0.0003**	11.7 ± 14.0	10.3 ± 11.6	0.0592
70 - 79						
Number of subjects	34	107		48	141	
Height (cm)	160.7 ± 6.3	163.3 ± 5.7	**0.0207**	150.4 ± 5.6	149.7 ± 4.7	0.3971
Body weight (kg)	58.2 ± 8.8	64.9 ± 9.9	**0.0006**	53.3 ± 6.2	54.9 ± 8.0	0.1964
Body mass index (kg/m^2)	22.5 ± 3.0	24.3 ± 2.9	**0.0031**	23.6 ± 3.2	24.5 ± 3.2	0.1118
Abdominal circumference (cm)	80.5 ± 9.4	87.2 ± 9.1	**0.0003**	79.4 ± 9.7	82.5 ± 9.9	0.0624
Hip circumference (cm)	88.2 ± 5.9	91.5 ± 5.3	**0.0031**	90.0 ± 4.6	89.9 ± 5.5	0.8791
Whole body reaction time (sec)	0.48 ± 0.16	0.49 ± 0.11	0.7586	0.50 ± 0.11	0.52 ± 0.13	0.2615
One leg with eye closed balance (sec)	6.2 ± 5.6	4.9 ± 4.2	0.1391	5.3 ± 3.7	4.9 ± 4.5	0.5943

Table 4. Comparison of clinical parameters in subjects without medications.

	Men			Women		
	60 - 69	70 - 79	*p*	60 - 69	70 - 79	*p*
Number of subjects	193	34		485	48	
Height (cm)	164.8 ± 5.0	160.7 ± 6.3	**<0.0001**	152.2 ± 5.1	150.4 ± 5.6	**0.0188**
Body weight (kg)	65.7 ± 8.2	58.2 ± 8.8	**<0.0001**	54.4 ± 7.4	53.3 ± 6.2	0.3148
Body mass index (kg/m^2)	24.2 ± 2.6	22.5 ± 3.0	**0.0013**	23.5 ± 3.0	23.6 ± 3.2	0.7063
Abdominal circumference (cm)	85.3 ± 8.8	80.5 ± 9.4	**0.0040**	77.1 ± 8.6	79.4 ± 9.7	0.0803
Hip circumference (cm)	91.7 ± 4.7	88.2 ± 5.9	**0.0001**	89.9 ± 5.0	90.0 ± 4.6	0.8551
Whole body reaction time (sec)	0.42 ± 0.08	0.48 ± 0.16	**0.0004**	0.44 ± 0.09	0.50 ± 0.11	**<0.0001**
One leg with eye closed balance (sec)	13.0 ± 13.5	6.2 ± 5.6	**0.0043**	11.7 ± 14.0	5.3 ± 3.7	**0.0016**

4. DISCUSSION

We evaluated whole body reaction time and one leg with eye closed balance in elderly Japanese. Especially in elderly subjects without medications, this standard mean value in 60's and 70's may provide a useful reference database for evaluating whole body reaction time and one leg with eye closed balance.

For preventing life-style related diseases, the level of maximal oxygen uptake and muscle strength was recommended in exercise and physical activity reference quantity for health promotion 2006 (EPARQ2006) by ministry of health, labor and welfare of Japan. However, according to other physical fitness *i.e.* agility and balance, the optimal level was not defined [10]. Reaction time is a physiological entity that has been linked as a causal factor in the incidence of falls in the elderly population [11]. In some literatures, whole body reaction time was analyzed in elderly Japanese. Higuchi *et al.* have reported that the whole body reaction time was increased with aging over 50's by 1028 Japanese, aged 20 - 85 years [12]. Cao *et al.* have reported that the effect of a 12-week combined exercise intervention program on physical performance and gait kinematics in community dwelling elderly women (n = 20). They showed that the whole body reaction time significantly decreased from 0.48 ± 0.07 sec to 0.45 ± 0.07 sec (6.4%) after intervention [11]. In addition, they also explored the effect of 12-month exercise and nutritional intervention by voluntary, homebased exercise [13].

According to one leg with eye closed balance, reference value for one leg balance time in elderly subjects varied widely from study to study [9], because various procedure are used to carry out the test *i.e.* eye-opened and eye-closed. At present, there is no consensus on whether it is better to perform the test with the eye open or closed. Potvin *et al.* reported and concluded that the test was more effective with the eyes closed [14]. The mean repo- rted one leg balance time of women aged 70 - 79 years ranging widely by as much as 6.9 - 32.9 sec [15].

In this study, we measured 730 men and 1329 women over the age of 60. In addition, we compared parameters between subjects with and without medications. This information gathered may serve as a useful reference database for evaluating whole body reaction time and one leg with eye closed balance in elderly Japanese.

Potential limitations remain in this study. First, our study was a cross sectional and not a longitudinal study. In addition, although there were differences of height or weight between 60's and 70's, cross sectional study design and/or difference of the birth cohort may affect these results. These greatly decrease the validity of the study. Second, the 2059 elderly subjects, all of whom wanted to change their lifestyle, underwent measurements for this study at Okayama Southern Institute of Health: they were therefore more health-conscious than the average person, especially may be in 70's. Thus, this study has a big selection bias. Third, the small sample size in especially 70's without medications might make it difficult to compare whole body reaction time and one leg with eye closed balance between subjects with and without medications. Therefore, this study does not have enough participants to obtain the standard mean value for the Japanese population. Further prospective, large sample size and community based studies are urgently needed in elderly Japanese.

5. ACKNOWLEDGEMENTS

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

REFERENCES

[1] Health and Welfare Statistics Association (2009) *Journal of Health and Welfare Statistics*, **56**, 39 (in Japanese).

[2] Sjostrom, L.V. (1992) Mortality of severely obese subjects. *The American Journal of Clinical Nutrition*, **55**, 516S-523S.

[3] Pouliot, M.C., Despres, J.P., Nadeeau, A., Moorjani, S., Prud'sHomme, D., Lupien, P.J. and Tremblay, A. (1992) Visceral obesity in men. Associations with glucose tolerance, plasma insulin, and lipoprotein levels. *Diabetes*, **41**, 826-834. doi:10.2337/diabetes.41.7.826

[4] Sandvik, L., Erikssen, J., Thaulow, E., Erikssen, G., Mundal, R. and Rodahl, K. (1993) Physical fitness as a predictor of mortality among healthy, middle-aged Norwegian men. *The New England Journal of Medicine*, **25**, 533-537. doi:10.1056/NEJM199302253280803

[5] Metter, E.J., Talbot, L.A., Schrager, M. and Conwit, R. (2002) Skeletal muscle strength as a predictor of all-cause mortality in healthy men. *The Journals of Gerontology Series A*, **57**, B359-B365. doi:10.1093/gerona/57.10.B359

[6] Miyatake, N., Miyachi, M., Tabata, I. and Numata, T. (2011) Evaluation of anthropometric parameters and physical fitness in elderly Japanese. *Environmental Health and Preventive Medicine*, **17**, 62-68.

[7] (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

[8] Miyatake, N., Miyachi, M., Nishikawa, H., Saito, T. and Numata, T. (2007) Comparison of whole body reaction time between Japanese men with and without metabolic syndrome. *International Journal of Sport and Health Sciences*, **5**, 122-124. doi:10.5432/ijshs.5.122

[9] Michikawa, T., Nishiwaki, Y., Takebayashi, T. and Toyama, Y. (2009) One-leg standing test for elderly populations. *Journal of Orthopaedic Science*, **14**, 675-685. doi:10.1007/s00776-009-1371-6

[10] National Institute of Health and Nutrition, Japan (2011). http://www.nih.go.jp/eiken/programs/pdf/epar2006.pdf

[11] Cao, Z.B., Maeda, A., Shima, N., Kurata, H. and Nishizono, H. (2007) The effect of a 12-week combined exercise intervention program on physical performance and gait kinematics in community-dwelling elderly women. *Journal of Physiological Anthropology*, **26**, 325-332. doi:10.2114/jpa2.26.325

[12] Higuchi, M., Okada, A., Hisamoto, S. and Miyano, M. (2008) Study of the results of measurements of Japanese physical fitness. *Japanese Journal of Physiological Anthropology*, **13**, 115-124 (in Japanese).

[13] Cao, Z.B., Tabata, I. and Nishizono, H. (2009) Good maintenance of physical benefits in a 12-month exercise and nutritional intervention by voluntary, home-based exercise: A 6-month follow-up of a randomized controlled trial. *Journal of Bone and Mineral Metabolism*, **27**, 182-189. doi:10.1007/s00774-008-0022-x

[14] Potvin, A.R., Syndulko, K., Tourtellotte, W.W., Lemmon, J.A. and Potvin, J.H. (1980) Human neurologic function and the aging process. *Journal of American Geriatrics Society*, **28**, 1-9.

[15] Rudisill, M.E. and Toole, T. (1993) Gender differences in motor performance of 50- to 79-year-old adults. *Perceptual and Motor Skills*, **77**, 939-947. doi:10.2466/pms.1993.77.3.939

