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Comparison of ventilatory threshold between subjects with and without proteinuria in Japanese

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ABSTRACT

We compared the levels of ventilatory threshold (VT) between subjects with and without proteinuria. We used data of 402 men and 413 women who were not taking any medications, aged 20 - 77 years, in this cross-sectional investigation study. Aerobic parameters at VT *i.e.* oxygen uptake, work rate and heart rate, and exercise habits were evaluated, which are considered to be cardio respiratory fitness. Proteinuria was measured by using urine strip devices. Forty three men (10.7%) and 29 women (7.0%) were diagnosed as having the proteinuria (± ≦). There were no significant relationships between proteinuria and exercise habits in both sexes after adjusting for age. Oxygen uptake at VT in subjects with proteinuria was significantly lower than that in subjects without proteinuria after adjusting for age in men. However, such link was not noted in women after adjusting for age (*p* = 0.9964). Finally, associations were attenuated after adjusting for age and exercise habits in both sexes. Among Japanese not taking medications, proteinuria might be a modifiable factor of VT, especially in Japanese men.

Keywords: Proteinruia; Ventilatory Threshold (VT); Exercise Habits

1. INTRODUCTION

Chronic kidney disease (CKD) has become an important public health challenge in Japan and it is a major risk factor for the end stage renal disease, cardiovascular disease and premature death [1,2]. For example, about 20% of adults have CKD, which is defined as kidney damage or a glomerular filtration rate (GFR) < 60 ml/min /1.73 m^2 for at least three months regardless of cause [3]. We have also previously reported in a cross-sectional study that the estimated glomerular filtration rate (eGFR) [4] in men with abdominal obesity and in women with hypertension was significantly lower than that in subjects without these components of metabolic syndrome [5]. In addition, we have also showed that proteinuria was closely linked to lower eGFR and it might be useful marker for CKD in Japanese [6].

The ventilatory threshold (VT), which is one of parameters of the cardio respiratory fitness, is defined as the upper limit of the aerobic exercise and is thought to serve as an accurate and reliable standard for exercise prescription [7]. Since the exercise intensity at VT is not harmful to cardiovascular function, it can be safely applied to patients with myocardial infarction as exercise prescription [8]. However, the link between cardio respiratory fitness using VT and proteinuria remains to be investigated.

In this study, we investigated cardio respiratory fitness evaluated by VT in Japanese and evaluated the clinical impact of proteinuria on VT in subjects not taking medications.

2. METHODS

2.1. Subjects

We used all data on 815 Japanese (402 men and 413 women) aged 20 - 77 years in a cross-sectional study. All subjects met the following criteria: 1) they had wanted to change their lifestyle *i.e.* diet and exercise habits, and had received an annual health checkup at Okayama Southern Institute of Health; 2) they had received VT, urine examination and anthropometric measurements as part of their annual health checkups; 3) they had received no medications for diabetes, hypertension, and/or dyslipidemia; and 4) they provided informed consent (**Table 1**).

The study was approved by the Ethics 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 [9].

2.3. Exercise Testing

A graded ergometer exercise protocol [10] was performed. Two hours after breakfast, a resting ECG was recorded and blood pressure was measured. Then, all participants were given graded exercise after 3 min of pedaling on an unloaded bicycle ergometer (Excalibur V2.0, Lode BV, Groningen, Netherlands). The profile of incremental workloads was automatically defined by the methods of Jones [10], in which the workloads reach the predicted VO_2 max in 10 min. A pedaling cycle of 60 rpm was maintained. Loading was terminated when the appearance of symptoms forced the subject to stop. During the test, ECG was monitored continuously together with the recording of heart rate (HR). Expired gas was collected and rates of oxygen consumption (VO_2) and carbon dioxide production (VCO_2) were measured breath-by-breath using a cardiopulmonary gas exchange system (Oxycon Alpha, Mijnhrdt b.v., Netherlands). VT was determined by the standard of Wasserman *et al* [7], Davis *et al* [11], and the V-slope method of Beaver [12] from VO_2, VCO_2 and minute ventilation (VE). At VT, VO_2 (ml/kg/min), work rate (W), and heart rate (beats/min) were measured and recorded.

2.4. Urine Examination

Urine samples were collected from the second-morning urine (before 10 a.m.) and examined within 1 hour. The urine examination was performed using urine strip tests (BAYER, Tokyo, Japan). The reagent strip was dipped directly into the urine sample. Just after dipping, the sample is graded as −: negative, ±: trace positive, +: positive (30 mg/dl), 2+: positive (100 mg/dl), 3+: positive (300 mg/dl) or 4+: positive (1000 mg/dl) by comparison with a standard color chart found on the container's label [13].

2.5. Exercise Habits

The data on exercise habits was obtained at interviews by well-trained staff in a structured way. The subjects were asked if they currently exercise (over the level of 30 minutes per time, two times per week and prolong duration for 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.

Table 1. Clinical profiles of enrolled subjects.

	Men			Women		
	Men ± SD	Minimum	Maximum	Men ± SD	Minimum	Maximum
Number of subjects	402			413		
Age	42.3 ± 11.5	20	77	45.1 ± 12.1	20	71
Height (cm)	169.7 ± 5.9	152.2	187.2	156.1 ± 5.5	141.7	176.1
Weight (kg)	78.8 ± 13.1	45.3	121.9	64.9 ± 12.0	39.9	116.9
Body mass index (kg/m^2)	27.3 ± 4.1	16.8	41.5	26.6 ± 4.8	15.4	48.7
Abdominal circumference (cm)	90.9 ± 10.8	62.5	130.0	81.5 ± 11.3	56.0	123.6
Hip circumference (cm)	98.5 ± 6.8	79.8	120.0	96.6 ± 8.5	72.5	132.0
Heart rate at rest (beat/min)	73.6 ± 12.4	43.0	117.0	73.2 ± 11.9	6.0	135.0
Systolic blood pressure (mm Hg)	137.3 ± 16.7	102.0	191.0	135.0 ± 20.9	82.0	188.0
Diastolic blood pressure (mm Hg)	86.1 ± 12.2	54.0	131.0	83.0 ± 12.8	50.0	122.0
Oxygen uptake at ventilatory threshold (ml/kg/min)	14.9 ± 3.9	8.7	33.9	12.6 ± 2.5	7.8	27.3
Work rate at ventilatory threshold (watt)	82.8 ± 24.5	35.0	190.0	51.2 ± 14.8	15.0	125.0
Heart rate at ventilatory threshold (beat/min)	105.9 ± 11.9	70.0	149.0	106.8 ± 11.7	71.0	147.0

2.6. Statistical Analysis

All data are expressed as mean ± standard deviation (SD) values. A statistical analysis was performed using an unpaired *t* test, χ^2 test, logistic regression analysis and covariance analysis, where $p < 0.05$ was considered to be statistically significant. We used the unpaired *t* test to compare parameters between subjects with and without proteinuria; the χ^2 test was used to evaluate the relationship between prevalence of proteinuria and exercise habits. Logistic regression analysis and covariance analysis were also used to adjust for parameters. ANOVA and Scheffe's F test were also used to compare among subjects with and without proteinuria and exercise habits.

3. RESULTS

Clinical profiles are summarized in **Table 1**. Oxygen uptake at VT was 14.9 ± 3.9 ml/kg/min in men and 12.6 ± 2.5 ml/kg/min in women. Prevalence of proteinuria in enrolled subjects is also summarized in **Table 2**. A total of 43 men (10.7%) and 29 women (7.0%) was diagnosed as having the proteinuria (± ≦).

We further evaluated the relationship between proteinuria and exercise habits (**Table 3**). Significant relationships between proteinuria and exercise habits were not noted in both sexes after adjusting for age.

We compared the parameters at VT between subjects with and without proteinuria (**Table 4**). In men, oxygen uptake at VT in subjects with proteinuria was significantly lower than that in subjects without proteinuria even after adjusting for age by using covariance analysis (p = 0.0114). It is well known that exercise habits are closely associated with ventilatory threshold [14], and significant difference of oxygen uptake at VT was attenuated after adjusting for age and exercise habits (p = 0.4628). The significant differences of work rate and heart rate at VT were not noted in men. In women, parameters at VT in subjects with proteinuria were not significant different compared to those in subjects without proteinuria.

We finally compared parameters at VT between subjects with and without proteinuria and exercise habits [A: proteinuria (–) exercise habits (+), B: proteinuria (–) exercise habits (–), C: proteinuria (+) exercise habits (+), D: proteinuria (+) exercise habits (–)] (**Table 5**). In men, oxygen uptake at VT in Group B and D was significantly lower than that in Group A. Heart rate at VT in Group D was significantly higher than that in Group A. In women, oxygen uptake at VT in Group B was significantly lower than that in Group A. Heart rate at VT in Group D was significantly higher than that in Group A.

4. DISCUSSION

In this study, we firstly evaluated the link between proteinuria and cardiorespilatory fitness using VT in Japanese without any medications. Proteinuria might be a modifiable factor of VT, especially in Japanese men.

It is well known that proteinuria and/or reduced renal function were closely associated with cardio vascular disease (CVD) [15,16]. Irie *et al* reported that they evaluated 30,764 men and 60,668 women aged 40 - 79 years for 10 years, and proteinuria and hypercreatinemia or reduced GFR and their combination were significant predictors of CVD and all-cause mortality [15]. Anavekar *et al* also showed that even mild renal disease

Table 2. Prevalence of proteinuria in enrolled subject.

	–		±		1+		2+		3+		Total
		%		%		%		%		%	
Men	359	89.3	21	5.2	14	3.5	5	1.2	3	0.7	402
Women	384	93.0	17	4.1	9	2.2	3	0.7	0	0.0	413

Table 3. Relationship between proteinuria and exercise habits.

	Proteinuria (–)	Proteinuria (± ≦)	p	p (After adjusting for age)
Men				
Exercise habits (+)	152	12	0.0688	0.0921
Exercise habits (–)	207	31		
Women				
Exercise habits (+)	105	4	0.1104	0.1667
Exercise habits (–)	279	25		

Table 4. Comparison of parameters at ventilatory threshold between subjects with and without proteinuria.

	Proteinuria (−)	Proteinuria (± ≦)	*p*	*P* (After adjusting for age)	*p* (After adjusting for age age and exercise habits)
	Men ± SD	Men ± SD			
Men					
Number of subjects	359	43			
Age	42.7 ± 11.5	39.2 ± 11.5	0.0564		
Oxygen uptake at ventilatory threshold (ml/kg/min)	15.1 ± 4.0	13.7 ± 2.8	**0.0275**	**0.0114**	0.4628
Work rate at ventilatory threshold (watt)	83.3 ± 25.3	78.7 ± 15.9	0.2440	0.3603	0.2947
Heart rate at ventilatory threshold (beat/min)	105.5 ± 12.0	109.1 ± 11.2	0.0591	0.4155	0.1050
Women					
Number of subjects	384	29			
Age	45.2 ± 12.2	42.6 ±11.0	0.2571		
Oxygen uptake at ventilatory threshold (ml/kg/min)	12.6 ± 2.5	12.3 ± 1.7	0.5751	0.9964	0.2939
Work rate at ventilatory threshold (watt)	51.2 ± 15.1	51.4 ± 10.0	0.9477	0.3446	0.2382
Heart rate at ventilatory threshold (beat/min)	106.4 ± 11.6	112.2 ± 12.5	**0.0102**	0.4685	0.2028

Table 5. Comparison of parameters of ventilatory threshold between subjects with and without proteinuria and exercise habits.

	Proteinuria (−)	Proteinuria (−)		Proteinuria (+)	Proteinuria (+)	
	Exercise habits (+)	Exercise habits (−)		Exercise habits (+)	Exercise habits (−)	
Men						
Number of subjects	152	207		12	31	
Oxygen uptake at ventilatory threshold (ml/kg/min)	16.7 ± 5.0	13.9 ±2.6	a	14.8 ± 4.1	13.2 ± 2.0	a
Work rate at ventilatory threshold (watt)	90.9 ± 31.0	77.7 ± 18.4	a	74.5 ± 16.3	80.3 ± 15.6	
Heart rate at ventilatory threshold (beat/min)	104.5 ± 13.1	106.1 ± 11.1		103.1 ± 12.4	111.4 ± 10.0	a
Women						
Number of subjects	105	279		4	25	
Oxygen uptake at ventilatory threshold (ml/kg/min)	13.4 ± 3.4	12.3 ± 2.1	a	10.6 ± 1.6	12.6 ± 1.6	
Work rate at ventilatory threshold (watt)	54.3 ± 18.9	50.0 ± 13.2		41.2 ± 9.5	53.0 ± 9.2	
Heart rate at ventilatory threshold (beat/min)	104.1 ± 12.0	107.3 ± 11.3		101.8 ± 11.6	113.8 ± 12.0	a

a: $p < 0.05$ vs Proteinuria (−), Exercise habits (+)

was considered a major risk factor for CVD after myocardial infarction in 14527 patients with acute myocardial infarction [16]. However, according to the link between reduced renal function and cardiorespiratory fitness, there were few studies especially in Japan. Okuno *et al* reported that they evaluated 109 community-dwelling frail elderly, aged 65 years and over, and they found that functional reach and tandem stance were significantly affected by eGFR [17]. Takhreen reviewed that relationship between exercise intervention and quality of life (QOL) in CKD patients. Exercising patients have shown improvements in physical fitness, psychological function, reaction times and lower extremity muscle strength, and these factors help improve QOL [18]. In this study, we solely evaluated the relationship between proteinuria and aerobic exercise level defined by VT in the Japanese without any medications. Exercise habits were not significantly linked to proteinuria in both sexes and the differences of parameters at VT between subjects with and without proteinuria were attenuated after adjusting for age and exercise habits in men. However, oxygen uptake at VT in women with proteinuria was not significantly lower than that in women without. In addition, we compared oxygen uptake at VT among subjects with and without proteinuria and exercise habits, and found that oxygen uptake at VT in Group D was the lowest among 4 groups in men. Oxygen uptake at VT in Group A was the highest among 4 groups in both sexes. Taken together, promoting exercise habits might be considered for improving aerobic exercise level, and proteinuria might be a modifiable factor of VT, especially in Japanese men.

Potential limitations still remain in this study. First, our study was a cross sectional and not a longitudinal study. Second, 402 men and 413 women 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 clear mechanism between proteinuria and oxygen uptake at VT. We have previously reported that brachial-ankle pulse wave velocity (baPWV) in subjects with reduced eGFR was significantly higher than that in subjects without [19]. Arterial stiffness might affect the results. In addition, low prevalence of proteinuria also affected the results, especially in women. To show this, further prospective studies are needed in the Japanese.

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Comparison of muscle strength between subjects with and without proteinuria

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ABSTRACT

We compared the levels of muscle strength between subjects with and without proteinuria. We used data of 721 men and 1063 women, aged 20 - 79 years, in this cross-sectional investtigation study. Parameters at muscle strength *i.e.* grip strength, leg strength and leg strength per body weight were evaluated. Proteinuria was measured by urine strip devices. Thirty five men (4.9%) and 27 women (2.5%) were diagnosed as having the proteinuria (+: 30 mg/dl) ≦). Leg strength and leg strength per body weight in men with proteinuria was significantly lower than that in men without proteinuria after adjusting for age. Grip strength in men with proteinuria was also lower than that in men without, but not at a significant level. However such link was not noted in women after adjusting for age. Among Japanese, proteinuria might be a modifiable factor of muscle strength in Japanese men.

Keywords: Proteinruia; Grip Strength; Leg Strength; Leg Strength per Body Weight

1. INTRODUCTION

Chronic kidney disease (CKD) has become a public health problem in Japan and it is a major risk factor for the end stage renal disease, cardiovascular disease and premature death [1,2]. About 20% of adults have CKD, which is defined as kidney damage or a glomerular filtration rate (GFR) <60 ml/min/1.73 m^2 for at least three months regardless of cause [3]. We have previously showed in a cross-sectional study that the estimated glomerular filtration rate (eGFR) [4] in men with abdominal obesity and in women with hypertension was significantly lower than that in subjects without these components of metabolic syndrome [5]. In addition, we have also reported that proteinuria was closely linked to lower cardiorespilatory fitness evaluated by ventilatory threshold (VT) [6].

It is also well known that low and declining muscle strength is associated with increased mortality, independent of physical activity and muscle mass [7]. 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 [8]. Although resistance training has been advocated as the most suitable exercise for increasing muscle strength [9,10], the link between proteinuria and muscle strength in a large sample of Japanese has not yet been investigated.

In this study, we investigated muscle strength evaluated by grip strength, leg strength and leg strength per body weight between subjects with and without proteinuria in Japanese.

2. SUBJECTS AND METHODS

2.1. Subjects

We used all data on 1,784 Japanese (721 men and 1063 women) aged 20 - 79 years in a cross-sectional study. All subjects met the following criteria: 1) they had wanted to change their lifestyle *i.e.* diet and exercise habits, and had received an annual health checkup at Okayama Southern Institute of Health; 2) they had received muscle strength, urine examination and anthropometric measurements as part of their annual health checkups; and 3) they provided informed consent (**Table 1**).

Table 1. Clinical profiles of enrolled subjects.

	Men			Women		
	Mean ± SD	Minimum	Maximum	Mean ± SD	Minimum	Maximum
Number of subjects	721			1063		
Age	47.9 ± 15.1	20	78	44.7 ± 13.9	20	79
Height (cm)	169.7 ± 6.0	143.7	186.7	156.9 ± 5.3	140.4	172.9
Body weight (kg)	71.3 ± 11.8	39.1	146.5	55.8 ± 9.6	29.3	118.0
Body mass index (kg/m^2)	24.7 ± 3.7	13.6	43.1	22.7 ± 3.8	14.1	44.9
Abdominal circumference (cm)	86.5 ± 10.3	62.4	135.0	78.3 ± 10.9	55.1	127.0
Right grip strength (kg)	42.4 ± 7.7	3.4	70.2	25.6 ± 5.1	7.1	45.1
Left grip strength (kg)	40.4 ± 7.6	4.6	63.1	24.3 ± 4.9	4.5	43.5
Leg strength (kg)	67.1 ± 17.5	19.0	140.0	41.5 ± 11.2	11.0	79.0
Leg strength per body weight	0.95 ± 0.22	0.28	1.65	0.75 ± 0.19	0.17	1.46

The study was approved by the Ethics 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 in standing subjects after normal expiration [11].

2.3. Muscle Strength

To assess muscle strength, grip and leg strength were measured [12]. 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 [12,13] which have also demonstrated good accuracy for this measurement [13]. 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 [13].

2.4. Urine Examination

Urine samples were collected from the second-morning urine (before 10 a.m.) and examined within 1 hour. The urine examination was performed using urine strip tests (BAYER, Tokyo, Japan). The reagent strip was dipped directly into the urine sample. Just after dipping, the sample is graded as –: negative, ±: trace positive, +: positive (30 mg/dl), 2+: positive (100 mg/dl), 3+: positive (300 mg/dl) or 4+: positive (1000 mg/dl) by comparison with a standard color chart found on the container's label [14].

2.5. Statistical Analysis

All data are expressed as mean ± standard deviation (SD) values. A statistical analysis was performed using an unpaired t test and covariance analysis, where $p < 0.05$ was considered to be statistically significant.

3. RESULTS

Clinical profiles are summarized in **Table 1**. Leg strength was 67.1 ± 17.5 kg in men and 41.5 ± 11.2 in women. Prevalence of proteinuria in enrolled subjects is also summarized in **Table 2**. A total of 35 men (4.9%) and 27 women (2.5%) was diagnosed as having the proteinuria (+: 30 mg/dl ≦).

We compared muscle strength between subjects with and without proteinuria (**Table 3**). In men, leg strength and leg strength per body weight in subjects with proteinuria was significantly lower than those in subjects without proteinuria even after adjusting for age by using covariance analysis (leg strength: $p = 0.0017$, leg strength per body weight: $p = 0.0495$). The significant differences of grip strength were not noted in men at a significant level (right grip strength: $p = 0.3691$, left grip strength: $p = 0.0670$). In women, parameters of muscle strength in subjects with proteinuria were not significant different from those in subjects without proteinuria (**Table 3**).

Table 2. Prevalence of proteinuria in enrolled subjects.

Proteinuria	20's	30's	40's	50's	60's	70's	Total	%
Men								
−	72	120	132	138	124	25	611	84.7
±	7	18	13	12	18	7	75	10.4
+	4	3	3	6	4	3	23	3.2
2+	0	3	2	1	3	1	10	1.4
3+	0	0	0	0	1	0	1	0.1
4+	0	0	0	0	1	0	1	0.1
Total	83	144	150	157	151	36	721	
Women								
−	165	224	202	207	144	30	972	91.4
±	13	15	10	18	8	0	64	6.0
+	5	1	3	5	2	0	16	1.5
2+	2	1	3	0	0	2	8	0.8
3+	1	2	0	0	0	0	3	0.3
Total	186	243	218	230	154	32	1063	

Table 3. Comparison of muscle strength between subjects with and without proteinuria.

	Proteinuria (− or ±)	Proteinuria (+≦)	*p*	*p* After adjusting for age
Men				
Number of subjects	686	35		
Age	47.8 ± 14.1	51.3 ± 16.2	0.1553	
Right grip strength (kg)	42.6 ± 7.6	39.6 ± 9.9	**0.0284**	0.3691
Left grip strength (kg)	40.5 ± 7.5	37.8 ± 8.9	**0.0379**	0.0670
Leg strength (kg)	67.3 ± 17.2	62.9 ± 21.7	0.1509	**0.0017**
Leg strength per body weight	0.95 ± 0.22	0.83 ± 0.26	**0.0017**	**0.0495**
Women				
Number of subjects	1036	27		
Age	44.8 ± 13.9	42.3 ± 16.3	0.3519	
Right grip strength (kg)	25.7 ± 5.1	23.5 ± 5.0	**0.0294**	0.7149
Left grip strength (kg)	24.3 ± 4.9	22.7 ± 4.4	0.0877	0.6094
Leg strength (kg)	41.5 ± 11.2	40.9 ± 11.5	0.7804	0.4926
Leg strength per body weight	0.75 ± 0.19	0.71 ± 0.18	0.2672	0.8468

4. DISCUSSION

In this study, we firstly evaluated the link between proteinuria and muscle strength *i.e.* grip strength, leg strength and leg strength per body weight in Japanese. Proteinuria might be a modifiable factor of muscle strength, especially in Japanese men.

Proteinuria and/or reduced renal function have been reported to be closely linked to cardio vascular disease (CVD) [15,16]. Anavekar *et al.* showed that even mild renal disease was considered a major risk factor for CVD after myocardial infarction in 14527 patients with acute myocardial infarction [15]. Irie *et al.* reported that they evaluated 30,764 men and 60,668 women aged 40 - 79 years for 10 years, and proteinuria and hypercreatinemia or reduced GFR and their combination were significant predictors of CVD and all-cause mortality [16]. We have also reported that proteinuria was a modifiable factor for cardiorespiratory fitness evaluated by VT [6]. However, according to the link between proteinuria and muscle strength, there were few studies especially in Japan. Protein-energy wasting is the term proposed to describe the reduction in the stores of energy and protein in patients CKD [17]. Muscle wasting is one of the best markers of protein-energy wasting in these patients [18]. Leal *et al.* reported that handgrip strength is a useful tool for continuous and systematic assessment of muscle mass related to nutritional status in patients on dialysis [19]. Takhreen reviewed that relationship between exercise intervention and quality of life (QOL) in CKD patients. Exercising patients have shown improvements in physical fitness, psychological function, reaction times and lower extremity muscle strength, and these factors help improve QOL [20]. In this study, we solely evaluated the relationship between proteinuria and muscle strength *i.e.* grip strength, leg strength and leg strength per body weight in the Japanese. The significant differences of leg strength and leg strength per body weight between men with and without proteinuria even after adjusting for age. However, muscle strength in women with proteinuria was not significantly lower than that in women without.

Potential limitations still remain in this study. First, our study was a cross sectional and not a longitudinal study. Second, 721 men and 1063 women in our study voluntarily underwent measurements: they were therefore more likely to be health-conscious compared with the average person. Second, we could not show clear mechanism between proteinuria and muscle strength. We have previously reported that brachial-ankle pulse wave velocity (baPWV) in subjects with reduced eGFR was significantly higher than that in subjects without [21]. In addition to protein-energy wasting, arterial stiffness might affect the results. Third, significant difference of muscle strength was not noted in women in this study. Low prevalence of proteinuria also affected the results, especially in women. To show this, further prospective studies are needed in the Japanese.

5. ACKNOWLEDGEMENTS

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

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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 anthropome tric, 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

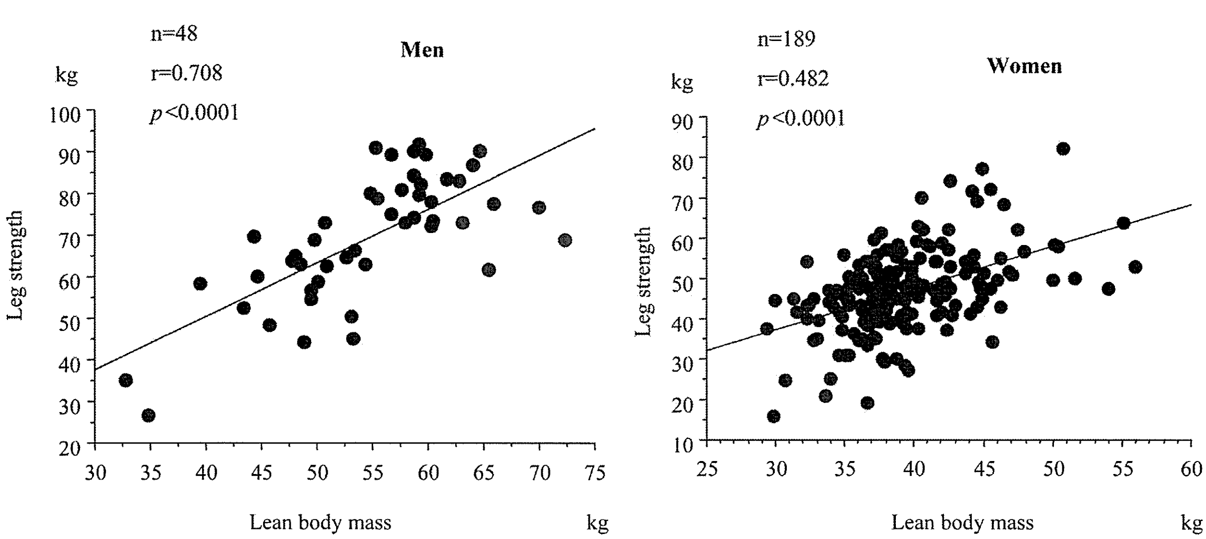

Figure 1. Simple correlation analysis between leg strength and lean body mass.

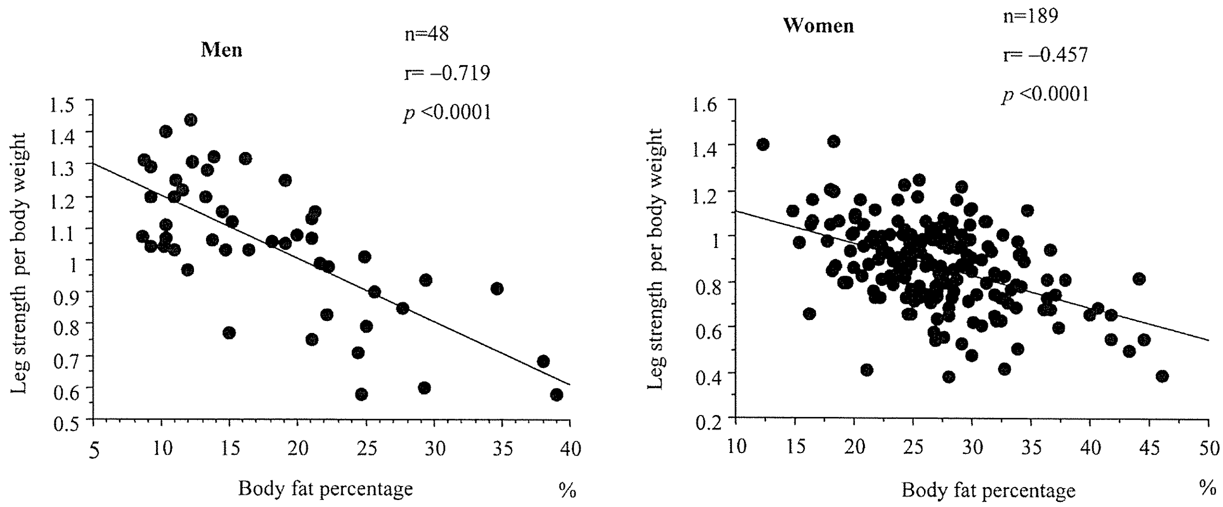

Figure 2. Simple correlation analysis between leg strength per body weight and body fat percentage.

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

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

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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

