Table 3 Changes in anthropometric and physical fitness parameters in the first and second analyses in all subjects

	Men			Women		
	60–69	70–79	*p*	60–69	70–79	*p*
First analysis						
Number of subjects	604	145		1,158	199	
Height (cm)	164.8 ± 5.3	162.7 ± 5.9	**<0.0001**	152.2 ± 4.9	149.9 ± 4.9	**<0.0001**
Body weight (kg)	66.5 ± 9.0	63.3 ± 9.9	**0.0002**	55.3 ± 7.8	54.8 ± 7.9	0.3793
Body mass index (kg/m^2)	24.5 ± 3.0	23.9 ± 3.0	**0.0313**	23.9 ± 3.2	24.4 ± 3.3	**0.0373**
Abdominal circumference (cm)	86.2 ± 9.1	85.6 ± 9.5	0.4998	78.3 ± 9.1	81.9 ± 10.2	**<0.0001**
Hip circumference (cm)	92.2 ± 5.4	90.7 ± 5.6	**0.0030**	90.3 ± 5.4	90.0 ± 5.4	0.5006
Right grip strength (kg)	37.3 ± 6.8	32.6 ± 6.9	**<0.0001**	22.5 ± 4.5	20.9 ± 4.4	**<0.0001**
Left grip strength (kg)	36.0 ± 6.6	30.8 ± 6.5	**<0.0001**	21.6 ± 4.4	20.0 ± 4.3	**<0.0001**
Leg strength (kg)	53.2 ± 12.9	41.9 ± 11.3	**<0.0001**	35.9 ± 8.5	31.8 ± 8.7	**<0.0001**
Leg strength per body weight	0.81 ± 0.19	0.67 ± 0.19	**<0.0001**	0.66 ± 0.16	0.59 ± 0.17	**<0.0001**
Flexibility (cm)	1.0 ± 9.9	−1.1 ± 11.3	**0.0278**	11.4 ± 8.0	10.7 ± 8.4	0.3205
Second analysis						
Number of subjects	255	47		228	39	
Oxygen uptake at VT (ml/kg/min)	12.7 ± 1.9	11.5 ± 1.7	**<0.0001**	12.0 ± 1.7	11.1 ± 1.5	**0.0024**
Work rate at VT (watt)	56.0 ± 12.6	40.4 ± 12.5	**<0.0001**	40.2 ± 10.2	29.7 ± 8.8	**<0.0001**
Heart rate at VT (beats/min)	96.6 ± 12.5	91.2 ± 14.0	**0.0080**	99.3 ± 12.8	96.9 ± 12.7	0.2747

Values are means ± SD. *p* values in boldface are significant

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greater, and BMI and abdominal circumference were significantly lower in those in their 60s than the values in women in their 70s. Muscle strength, oxygen uptake at VT, and work rate at VT in those in their 60s were significantly higher than the values in women in their 70s.

We further analyzed clinical parameters, comparing them between subjects with and without medications (Table 4). There were significant differences in anthropometric parameters (except for height), muscle strength, flexibility, and work rate at VT between men with and without medications. In women, there were also significant differences in body weight, BMI, abdominal circumference, and muscle strength between the two groups.

In addition, in men in their 60s, muscle strength and flexibility in subjects without medications were significantly higher than these values in subjects with medications. In women, body weight, BMI, abdominal circumference, and hip circumference were significantly lower, and grip strength and leg strength per body weight were significantly higher in subjects without medications than these values in subjects with medications (Table 4).

In men in their 70s, anthropometric parameters were significantly lower and leg strength per body weight was significantly higher in men without medications than these values in men with medications. Muscle strength in women without medications was significantly higher than that in women with medications (Table 4).

We found that there were significant differences in some parameters between subjects with and without medications. We finally compared parameters between subjects in their 60s and subjects in their 70s in without medications (Table 5). In men, anthropometric parameters and muscle strength in those in their 70s were significantly lower than these values in men in their 60s. In women, only abdominal circumference in those in their 70s was higher than that in women in their 60s. There were no differences in other parameters between subjects in their 60s and those in their 70s.

Discussion

We evaluated anthropometric parameters, muscle strength, flexibility, and aerobic exercise levels in elderly Japanese. Especially in elderly subjects without medications, this mean value for those in their 60s and 70s may provide a useful database for evaluating anthropometric parameters and physical fitness.

It has been well reported that there is significant loss in muscle strength with aging [15, 16]. Aging is associated with alterations in body composition; there is an increase in body fat percentage and a concomitant decline in lean body mass [17]. Aging, therefore, results in substantial alterations in body composition, with a marked reduction in

Table 4 Comparison of anthropometric and physical fitness parameters between subjects with and without medications as classified by age groups

	Men			Women		
	Medication (−)	Medication (+)	*p*	Medication (−)	Medication (+)	*p*
All subjects						
First analysis						
Number of subjects	229	520		540	817	
Height (cm)	164.2 ± 5.4	164.5 ± 5.5	0.4997	152.0 ± 5.2	151.8 ± 4.9	0.3762
Body weight (kg)	64.6 ± 8.7	66.5 ± 9.5	**0.0097**	54.4 ± 7.6	55.8 ± 8.0	**0.0015**
Body mass index (kg/m^2)	23.9 ± 2.7	24.5 ± 3.1	**0.0076**	23.6 ± 3.1	24.2 ± 3.3	**0.0002**
Abdominal circumference (cm)	84.7 ± 9.0	86.7 ± 9.2	**0.0055**	77.4 ± 9.0	79.8 ± 9.4	**<0.0001**
Hip circumference (cm)	91.3 ± 5.0	92.2 ± 5.6	**0.0305**	89.9 ± 5.2	90.5 ± 5.5	0.0646
Right grip strength (kg)	37.5 ± 6.6	35.9 ± 7.2	**0.0028**	23.0 ± 4.4	21.8 ± 4.6	**<0.0001**
Left grip strength (kg)	35.8 ± 6.7	34.6 ± 7.0	**0.0213**	22.0 ± 4.2	21.0 ± 4.6	**<0.0001**
Leg strength (kg)	53.1 ± 12.8	50.2 ± 13.5	**0.0059**	36.2 ± 8.0	34.7 ± 9.0	**0.0013**
Leg strength per body weight	0.83 ± 0.19	0.76 ± 0.19	**<0.0001**	0.67 ± 0.15	0.63 ± 0.17	**<0.0001**
Flexibility (cm)	2.3 ± 10.8	−0.2 ± 9.9	**0.0023**	11.7 ± 8.0	11.0 ± 8.1	0.1189
Second analysis						
Number of subjects	33	269		55	212	
Oxygen uptake at VT (ml/kg/min)	12.9 ± 1.8	12.4 ± 2.0	0.2280	11.8 ± 1.6	11.9 ± 1.7	0.7549
Work rate at VT (watt)	59.0 ± 12.8	52.9 ± 13.8	**0.0176**	40.4 ± 9.2	38.2 ± 10.8	0.1651
Heart rate at VT (beats/min)	96.7 ± 9.9	95.6 ± 13.2	0.6505	99.7 ± 12.5	98.8 ± 12.8	0.6563
60–69						
First analysis						
Number of subjects	195	409		490	668	
Height (cm)	164.8 ± 5.0	164.8 ± 5.5	0.9816	152.2 ± 5.1	152.2 ± 4.8	0.8692
Body weight (kg)	65.7 ± 8.2	66.9 ± 9.4	0.1204	54.5 ± 7.6	56.0 ± 7.9	**0.0016**
Body mass index (kg/m^2)	24.2 ± 2.6	24.6 ± 3.1	0.0755	23.5 ± 3.1	24.1 ± 3.3	**0.0010**
Abdominal circumference (cm)	85.4 ± 8.8	86.6 ± 9.2	0.1416	77.2 ± 8.8	79.2 ± 9.2	**0.0002**
Hip circumference (cm)	91.8 ± 4.7	92.4 ± 5.7	0.1956	89.9 ± 5.2	90.6 ± 5.5	**0.0304**
Right grip strength (kg)	38.2 ± 6.2	36.8 ± 7.0	**0.0168**	23.1 ± 4.5	22.1 ± 4.5	**0.0006**
Left grip strength (kg)	36.8 ± 6.3	35.6 ± 6.7	**0.0427**	22.0 ± 4.3	21.3 ± 4.5	**0.0117**
Leg strength (kg)	54.7 ± 12.4	52.5 ± 13.1	**0.0472**	36.3 ± 8.0	35.5 ± 8.9	0.1073
Leg strength per body weight	0.84 ± 0.19	0.79 ± 0.19	**0.0028**	0.67 ± 0.15	0.64 ± 0.17	**0.0018**
Flexibility (cm)	2.5 ± 10.5	0.2 ± 9.6	**0.0087**	11.6 ± 8.0	11.1 ± 8.0	0.3002
Second analysis						
Number of subjects	30	225		53	175	
Oxygen uptake at VT (ml/kg/min)	12.9 ± 1.8	12.7 ± 1.9	0.5373	11.8 ± 1.7	12.1 ± 1.7	0.3367
Work rate at VT (watt)	59.5 ± 12.5	55.6 ± 12.6	0.1052	40.5 ± 9.4	40.1 ± 10.2	0.7872
Heart rate at VT (beats/min)	97.1 ± 10.2	96.5 ± 12.8	0.8199	99.6 ± 12.6	99.3 ± 12.8	0.8459
70–79						
First analysis						
Number of subjects	34	111		50	149	
Height (cm)	160.7 ± 6.3	163.3 ± 5.7	0.0243	150.4 ± 5.5	149.7 ± 4.7	0.4049
Body weight (kg)	58.2 ± 8.8	64.9 ± 9.7	**0.0005**	53.8 ± 7.4	55.1 ± 8.1	0.3041
Body mass index (kg/m^2)	22.5 ± 3.0	24.3 ± 2.9	**0.0025**	23.9 ± 3.5	24.6 ± 3.2	0.1770
Abdominal circumference (cm)	80.5 ± 9.4	87.2 ± 9.0	**0.0003**	80.0 ± 10.9	82.6 ± 9.9	0.1158
Hip circumference (cm)	88.2 ± 5.9	91.5 ± 5.3	**0.0029**	90.2 ± 4.7	90.0 ± 5.6	0.7944
Right grip strength (kg)	33.4 ± 7.4	32.3 ± 6.8	0.3916	22.7 ± 4.0	20.3 ± 4.4	**0.0006**
Left grip strength (kg)	30.6 ± 6.5	30.9 ± 6.6	0.8323	21.9 ± 3.9	19.4 ± 4.3	**0.0004**

Table 4 continued

	Men			Women		
	Medication (−)	Medication (+)	*p*	Medication (−)	Medication (+)	*p*
Leg strength (kg)	43.5 ± 11.3	41.5 ± 11.4	0.3593	34.8 ± 8.1	30.8 ± 8.6	**0.0043**
Leg strength per body weight	0.76 ± 0.21	0.65 ± 0.17	**0.0015**	0.65 ± 0.16	0.57 ± 0.16	**0.0010**
Flexibility (cm)	1.0 ± 12.4	−1.8 ± 11.0	0.2127	12.1 ± 8.0	10.3 ± 8.6	0.1793
Second analysis						
Number of subjects	3	44		2	37	
Oxygen uptake at VT (ml/kg/min)	12.8 ± 1.8	11.4 ± 1.7	0.1685	11.9 ± 1.0	11.1 ± 1.5	0.4774
Work rate at VT (watt)	53.3 ± 17.6	39.5 ± 11.9	0.0642	37.5 ± 3.5	29.2 ± 8.8	0.1980
Heart rate at VT (beats/min)	93.0 ± 7.2	91.0 ± 14.4	0.8183	100.5 ± 13.4	96.7 ± 12.8	0.6887

Values are means ± SD. *p* values in boldface are significant

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Table 5 Changes in anthropometric and physical fitness parameters in the first and second analyses in subjects without medications

	Men			Women		
	60–69	70–79	*p*	60–69	70–79	*p*
First analysis						
Number of subjects	195	34		490	50	
Height (cm)	164.8 ± 5.0	160.7 ± 6.3	**<0.0001**	152.2 ± 5.1	150.4 ± 5.5	0.0189
Body weight (kg)	65.7 ± 8.2	58.2 ± 8.8	**<0.0001**	54.5 ± 7.6	53.8 ± 7.4	0.5481
Body mass index (kg/m^2)	24.2 ± 2.6	22.5 ± 3.0	**0.0012**	23.5 ± 3.1	23.9 ± 3.5	0.4736
Abdominal circumference (cm)	85.4 ± 8.8	80.5 ± 9.4	**0.0035**	77.2 ± 8.8	80.0 ± 10.9	**0.0383**
Hip circumference (cm)	91.8 ± 4.7	88.2 ± 5.9	**0.0001**	89.9 ± 5.2	90.2 ± 4.7	0.7027
Right grip strength kg)	38.2 ± 6.2	33.4 ± 7.4	**<0.0001**	23.1 ± 4.5	22.7 ± 4.0	0.5974
Left grip strength (kg)	36.8 ± 6.3	30.6 ± 6.5	**<0.0001**	22.0 ± 4.3	21.9 ± 3.9	0.8747
Leg strength (kg)	54.7 ± 12.4	43.5 ± 11.3	**<0.0001**	36.3 ± 8.0	34.8 ± 8.1	0.1953
Leg strength per body weight	0.84 ± 0.19	0.76 ± 0.21	**0.0250**	0.67 ± 0.15	0.65 ± 0.16	0.3706
Flexibility (cm)	2.5 ± 10.5	1.0 ± 12.4	0.4562	11.6 ± 8.0	12.1 ± 8.0	0.6805
Second analysis						
Number of subjects	30	3		53	2	
Oxygen uptake at VT (ml/kg/min)	12.9 ± 1.8	12.8 ± 1.8	0.9404	11.8 ± 1.6	11.9 ± 1.0	0.9520
Work rate at VT (watt)	59.5 ± 12.5	53.3 ± 17.6	0.4342	40.5 ± 9.4	37.5 ± 3.5	0.6526
Heart rate at VT (beats/min)	97.1 ± 10.2	93.0 ± 7.2	0.5071	99.6 ± 12.6	100.5 ± 13.4	0.9253

Values are means ± SD. *p* values in boldface are significant

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skeletal muscle mass. It has also been well reported that there is significant loss in oxygen uptake at the ventilatory threshold (VT) –which is also considered an accurate and reliable parameter of aerobic exercise level [13]–with aging [18, 19]. Miura reported that oxygen uptake at VT was significantly correlated with age (men, $r = -0.626$; women, $r = -0.578$) in 610 Japanese [18]. Sanada et al. reported that a negative correlation was noted between oxygen uptake at VT and age in 1,463 Japanese [19]. However, there are few reports of the evaluation of physical fitness in elderly Japanese. In the previous studies noted above, the number of subjects over the age of 70 was 20 in men and 16 in women [18], and 65 in men and 13 in women [19]. Especially, there are no accurate reference data for physical fitness in Japanese subjects over the age of 70 without medications. We have previously reported on changes in maximal oxygen uptake in subjects aged 20–69 years [20]. In the present study, we evaluated anthropometric parameters, muscle strength, flexibility, and aerobic exercise levels in subjects over the age of 60. We measured anthropometric parameters, muscle strength, and flexibility in 145 men and 199 women in their 70s.

In addition, we compared parameters between subjects with and without medications. Although we evaluated VT in only 3 men and 2 women in their 70s without medications, this information gathered should serve as quite a useful database for evaluating anthropometric parameters, muscle strength, flexibility, and aerobic exercise levels in elderly Japanese subjects.

We found a difference in anthropometric parameters and muscle strength between men with and without medications in their 60s and 70s. However, in women, abdominal circumference in those in their 70s was higher than that in women in their 60s, while other parameters in women in their 70s were similar to values in those in their 60s. Sanada et al. [19] also reported that, in women, fat-free body mass in those in their 70s (41.5 ± 3.5 kg) was similar to that in women in their 60s (40.0 ± 4.4 kg), while in men, fat-free mass in those in their 70s (52.9 ± 4.1 kg) was lower than that in men in their 60s (55.3 ± 52.9 kg). Previous exercise habits, current exercise habits, and sample size may affect the results.

There are potential limitations in the present study. First, our study was a cross-sectional and not a longitudinal study. Second, the 2,106 elderly subjects, all of whom wanted to change their lifestyle, underwent measurements for this study: they were therefore more health-conscious than the average person. The 569 subjects selected in the second analysis underwent aerobic exercise testing; they were therefore more health-conscious than most of the subjects in the first analysis. Third, the small sample size, especially of subjects in their 70s without medications, might make it difficult to compare aerobic exercise levels between subjects with and without medications, and to compare these levels between subjects in their 60s and those in their 70s. In addition, the death rate in subjects aged 75–79 is higher than that in those aged 70–74 [21]. Therefore, it is well expected that there are differences in physical fitness between subjects aged 70–74 and those aged 75–79. Further large-sample-size and prospective studies are needed in elderly Japanese.

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Chair-rising and 3-min walk: A simple screening test for functional mobility

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ABSTRACT

Aging induces decrease of locomotor capacity and its decrease is associated with an increased risk of falls. Several lines of evidence indicate that both change in muscle power and aerobic fitness are causative. Mobility tests are usually based on a maximal exercise stress test; however, this test is often difficult and sometimes frightening to older persons. Therefore, the objective of this study was to examine age and gender differences in 3-min walk distance test (3WDT), and time of chair-rising test (CRT) of functional mobility. 153 men and 159 women aged from 20 to 78 years were recruited as subjects of the present study. The body composition measured the height, body mass (BM), body mass index (BMI), lean tissue mass (LTM), and waist circumference (WC). The Functional mobility tests measured the peak oxygen uptake (V_{O2peak}), 3WDT, leg extension strength (LES), and times of CRT. Both in men and women, height and BMI, WC decreased and increased, respectively, with age. Height, BM, LTM, WC in men are higher than in women. We found no correlation between ages and 3WDT in women and a significant, negative correlation in men. All parameters of fitness performance were negatively correlated with age. Both in men and women, all parameters of fitness performance were positively correlated with sex. Both in men and women, V_{O2peak}, 3WDT, and LES decreased with age. All parameters of fitness performance in men are higher than in women. Both in men and women were observed for the correlation between 3WDT and V_{O2peak}, LES and CRT respectively. Although as the correlation coefficient between 3WTD and V_{O2peak}, LES and CRT were low (r = 0.28 - 0.38), an error may occur, this study shows that 3WDT and CRT test can be a feasible method of providing the information for muscle power and aerobic fitness, possibly avoiding the need for a maximal stress test.

Keywords: Peak Oxygen Uptake; 3-Min Walk Distance Test; Leg Extension Strength; Chair-Rising Test; Mobility

1. INTRODUCTION

Aging induces decrease of locomotor capacity and its decrease is associated with an increased risk of falls. Current demographic trends show that the number of older people is rapidly increasing. In fact, mobility is essential for functional independence, reduced risk of fall, and quality of life [1-3]. In older persons, disability is caused by both change in muscle power and aerobic fitness is causative. Several studies have shown that there is a decline in the ability to perform muscle power-related tests as age increases with a significant decline commencing at approximately 40 years of age. Similarly, physical performance decrease with age. These age-related changes in the performance of functional mobility measures and physiological domains are also associated with an increased risk of falls, ongoing disability and admission into residential aged care [3,4].

Mobility tests are commonly used to assess function and frailty in older persons. Mobility tests are usually based on a maximal exercise stress test; however, this test is often difficult and sometimes frightening to older persons. 3-min walk distance test and chair-rising test are low of risk. There are little data available on the age-related changes and gender differences in the performance of these tests. The development of age stratified normative data for these commonly used functional mobility tests could assist in the targeting of interventions for people who exhibit a decline in their functional status at an early stage, prior to the occurrence of falls and the onset of disability. Therefore, the aim of this study was to provide reference data and examine age and gender differences in 3-min walk distance test, and time of rising chair without using the arms. The second aim was to provide data available on the age-related changes in the performance of these tests. The information provided is relevant to new functional mobility tests in older persons.

2. METHODS

2.1. Participants

One hundred and fifty-three men and one hundred and fifty-nine women aged from 20 to 78 years (44.3 ± 14.8 years) were recruited as subjects of the present study. None of the subjects had any chronic diseases or were taking any medications that could affect the study variables. All subjects provided written informed consent according to local institute policy before the measurement of physical fitness. All subjects were classified into six groups by sex and age: 20 to 39-year-old men, 40 to 59-year-old men, 60 to 79-year-old men, 20 to 39-year-old women, 40 to 59-year-old women, and 60 to 79-year-old women. This study has been approved by the Committee on the Use of Human Research Subjects of Matsumoto University, and also performed in accordance with the ethical standards of the IJSM [5]. Participants were fully informed of the purpose and risks of participating in this investigation and signed informed consent documents prior to testing. The participants characteristics are described in **Table 1**.

2.2. Anthropometrics

The body composition measured the height, body mass (BM), body mass index (BMI), lean tissue mass (LTM), and waist circumference (WC). Height was measured to the nearest 0.1 cm using a stadiometer (YKH-23; Yagami Inc., Japan). BM, BMI, and LTM were measured using a body composition meter (BC-118E; TANITA Inc., Japan).

2.3. Functional Mobility Tests

The four tests were administered in a single session. Timed tests were measured with stopwatch with an accuracy of 0.01s.

2.4. Leg Extension Strength (LES)

LES was assessed using GT-330 (OG-giken, Japan). The individuals were seated in the chair of the dynamometer, and were stabilized with straps across the waist and thighs throughout the test. Bilateral reciprocal contractions at the knee were measured at a preset angle of 120˚. An index of strength was determined by summing peak extension torque. The average value in two times the right and left was assumed to be measurements.

2.5. Peak Oxygen Uptake (V_{O2peak})

V_{O2peak} was measured using a maximal graded exercise test (GTX) with bicycle erometers (Monark Ergomedic 828E, Sweden). The initial workload was 30 - 60 W, and the work rate was increased thereafter by 15 $W \cdot min^{-1}$ until subject could not maintain the required pedaling frequency (60 rpm). Heart rate (WEP-7404; NIHON KOHDEN Corp., Japan) and a rating of perceived exertion were monitored throughout the exercise. During the progressive exercise test, the expired gas of subjects was collected, and the rates of oxygen consumption and Carbon dioxide production were measured and averaged over 30-s intervals using an automated breath-by-breath gas analyzing system (Aeromonitor AE-280S; Minato Medical Science, Japan).

2.6. Chair-Rising Test (CRT)

In this test, participants were asked to rise from a standard height (43 cm) chair without armrests, ten times as fast as possible with their arms folded. Arms are crossed in front of the chest. Participants undertook the test barefoot. The time from the initial seated position to the final seated position after completing ten stands was the test measure. Two trials were to be performed. The higher value in two trials was assumed to be measurements.

Table 1. Physical characteristic of the study subjects, mean ± SD.

	All	Age 20 - 30 years	Age 40 - 50 years	Age 60 - 70 years	All	Age 20 - 30 years	Age 40 - 50 years	Age 60 - 70 years
		Men						Women
N	153	79	44	30	159	69	54	36
Height (cm)	169.7 ± 6.7	171.0 ± 6.6	170.5 ± 6.0	$164.9 \pm 5.7^{**\#}$	$157.6 \pm 5.6^{+++}$	159.6 ± 5.1	158.4 ± 4.3	$152.7 \pm 5.1^{***\#\#\#}$
BW (kg)	62.8 ± 7.8	62.2 ± 8.1	64.7 ± 6.5	61.7 ± 8.3	$50.8 \pm 6.1^{+++}$	50.8 ± 6.2	52.3 ± 6.4	$48.4 \pm 4.9^{\#}$
BMI (kg/m^2)	21.8 ± 2.2	21.2 ± 2.0	$22.2 \pm 1.9^{**}$	$22.6 \pm 2.7^{*}$	$20.4 \pm 2.1^{+++}$	19.9 ± 2.1	$20.8 \pm 2.1^{*}$	$20.8 \pm 2.2^{*}$
MV (kg)	50.4 ± 5.0	50.7 ± 5.1	51.5 ± 4.3	48.1 ± 5.1	$35.6 \pm 3.1^{+++}$	36.1 ± 3.2	36.3 ± 2.8	$33.4 \pm 2.2^{***\#\#\#}$
WS (cm)	77.4 ± 7.2	74.6 ± 6.8	$79.2 \pm 5.7^{***}$	$82.3 \pm 7.1^{***}$	$73.0 \pm 6.8^{+++}$	70.3 ± 5.6	$74.0 \pm 6.0^{**}$	$76.4 \pm 7.9^{***\#}$

SD = Standard Deviation; BW = Body Weight; BMI = Body Mass Index; MV = Muscle Volume; Waist Size = WS; $^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$ vs Age 20 - 30 years $^{\#\#\#}p < 0.001$, $^{\#\#}p < 0.01$, $^{\#}p < 0.05$ vs Age 40 - 50 years $^{+++}p < 0.001$ vs men.

2.7. 3-Min Walk Distance Test (3WDT)

The participants performed the 3WDT in a 50-m indoor corridor with marks every second metre on the side of the walkway. They were instructed to wear comfortable shoes. The instructions were to walk as many lengths as possible in three minutes, without running or jogging. To clarify the instructions, the participants were also told to walk as fast as possible. Information was given during the test by telling the participants how many minutes they had walked or minutes remaining. Finally, the total 3WDT was measured.

2.8. Statistical Analyses

Results are expressed as mean values with their standard errors. The statistical significance (p, 0.05) of differences was determined by 2-way ANOVA followed by a Tukey post hoc analysis. Correlations between a fitness performance and another fitness performance were assessed by Pearson's correlation coefficients (r).

3. RESULTS

The physical characteristic of the study is described in **Table 1**. Height decreased and BMI, WC increased in men, respectively, with age. Height, BM and LTM decreased and BMI and WC increased in women. All physical characteristic in men are higher than in women. **Table 2** reports the correlation between ages and functional mobility tests. All functional mobility tests, except for 3WDT in women, were negatively correlated with age (**Table 2**). **Table 3** reports the parameters of functional mobility tests of the study subjects. All parameters of functional mobility tests were positively correlated with sex. All parameters of functional mobility tests in men are higher than in women. Both in men and women were observed for the correlation between 3WDT and V_{O2peak}, LES and CRT respectively. **Figure 1** reports the relationship between 3WDT and V_{O2peak} in the men (n = 153) and women (n = 159). Both in men and women, 3WTD was correlated with V_{O2peak} (r = 0.31 and 0.31, respectively; $p < 0.0001$). **Figure 2** reports the relationship between LES and CRT in the men (n = 153) and women (n = 159). Both in men and women, LES was correlated with CRT (r = 0.38 and 0.28, respectively; $p < 0.001$).

4. DISCUSSION

3WDT and CRT is the simplest test of the V_{O2peak} test and leg strength, respectively. This study adds to the accumulating literature investigating the dynamic relations between body compositions and the functional mobility test in the elderly.

Body composition varies according to age, sex, and race. Older adults tend to lose fat-free mass and gain fat mass. WC is a reliable marker of mortality in older adults [6-8] and muscle mass, as represented by lean mass, is associated with survival. In the present study, height, BMI and WC were decreased and increased, respectively, with age in men and women. Moreover, Height, BM, LTM and WC in men is higher than in women.

The Functional mobility tests measured the V_{O2peak}, 3WDT, LES, and CRT. The study findings revealed significant age-related differences in all functional mobility tests examined. These findings confirm those of previous studies and indicate that when compared with young people, older people exhibit slower comfortable walking speed [5,9], reduced ability to quickly rise from a chair [3,10]. These age-related differences in functional mobility have been attributed to impaired sensorimotor function [11,12], in particular reduced lower extremity strength and power [13-15], but also increased fear of falling [8] and reduced aerobic capacity [16].

Table 2. Correlation of the variables of interest with age.

	CRT (sec)	3WDT (m)	LE (n - m)	V_{O2max} (ml/kg/min)
Women	0.19^{*}	−0.12	-0.32^{**}	-0.49^{**}
Men	0.42^{**}	-0.32^{**}	-0.32^{**}	-0.51^{**}

CRT = chair-rising test; 3WDT = 3-min walk distance test; LE = leg extension; V_{O2max} = maximum oxygen uptake; Pearsons correlation coefficients. $^{**}p < 0.001$, $^{*}p < 0.05$.

Table 3. Parameters of fitness performance of the study subjects, mean ± SD.

	All	Age 20 - 30 years	Age 40 - 50 years	Age 60 - 70 years	All	Age 20 - 30 years	Age 40 - 50 years	Age 60 - 70 years
	Men				Women			
N	153	79	44	30	159	69	54	36
V_{O2max} (ml/kg/min)	36.7 ± 9.1	40.7 ± 8.1	$35.0 \pm 7.7^{***}$	$28.6 \pm 6.9^{***\#\#\#}$	$27.8 \pm 6.4^{+++}$	30.6 ± 6.5	$27.4 \pm 5.3^{**}$	$23.0 \pm 4.4^{***\#\#\#}$
CRT (sec)	10.2 ± 2.4	9.5 ± 1.8	9.6 ± 1.7	$12.8 \pm 3.1^{***\#\#\#}$	$11.1 \pm 2.5^{+++}$	10.7 ± 2.7	11.2 ± 2.3	11.6 ± 2.5
3WDT (m)	390.0 ± 58.7	403.3 ± 58.9	390.7 ± 38.9	$353.7 \pm 68.0^{***\#\#}$	$350.6 \pm 34.1^{+++}$	351.1 ± 34.6	358.2 ± 31.6	$338.4 \pm 34.4^{\#}$
LE (n - m)	630.1 ± 137.0	669.3 ± 130.8	622.8 ± 136.5	$537.7 \pm 108.3^{***\#\#}$	$409.2 \pm 106.3^{+++}$	430.1 ± 118.8	420.3 ± 91.1	$352.6 \pm 81.7^{***\#\#}$

SD = Standard Deviation; CRT = chair-rising test; 3WDT = 3-min walk distance test; LE = leg extension; V_{O2max} = maximum oxygen uptake.

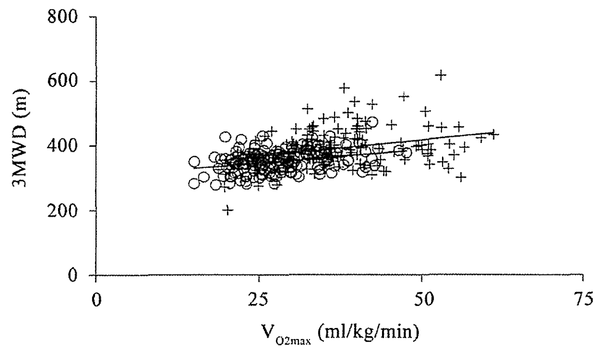

Figure 1. Relationship between 3WTD and V_{O2max} in the men (n = 153) and women (n = 159). The 3MWD was to walk as many lengths as possible in three minutes. V_{O2max} was to until subject could not maintain the required pedaling frequency (60 rpm).

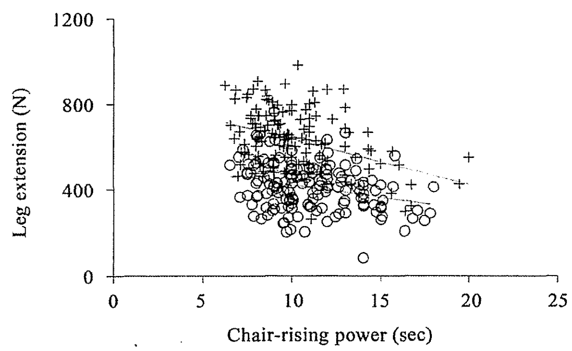

Figure 2. Relationship between LE and CRT in the men (n = 153) and women (n = 159). The LE was to the highest in four times in total the right and left two times value. Chair-rising times from the initial seated position to the final seated position after completing ten stands were the test measure.

A remarkable decline, however, was observed in the performance variables (muscle strength and aerobic capacity) assessed by the CRT and by 3WDT. The CRT was measured power during an activity which involves raising the centre of gravity. Several studies have found that performance in the CRT is a strong predictor of incident disability, mortality, falls, hospitalization and health care resources consumption. Hence, CRT can be regarded as an indicator of physical performance at old age. In the present study, both in men and women were observed for the correlation between 3WDT and V_{O2peak}, LES and CRT respectively, and the fact that this test can be a feasible method of providing the information for muscle power and aerobic fitness, possibly avoiding the need for a maximal stress test.

Significant correlations among all the functional mobility tests in the older group indicate that older adults who performed poorly in one test were likely to perform poorly in all the other tests. The results from the present study, the functional mobility tests of 3WDT and CRT were found to give an idea of the physical decline with age in fit elderly without any maximal exercise stress.

In conclusion, first, this study provides significant age-related differences in performance were found in tests of coordinated the V_{O2peak}, 3WDT, LES, and CRT, with older women performing worse than older men in all tests. Secondly, this study shows that 3WDT and CRT can be a feasible method of providing the information for muscle power and aerobic fitness, possibly avoiding the need for a maximal stress test.

Limit

As the correlation coefficient between 3WTD and V_{O2peak}, LES and CRT were low (r = 0.28 - 0.38), an error may occur. Accordingly, this study shows that 3WDT and CRT as estimate method for aerobic fitness and muscle power can be a feasible, if we measure many people as method briefly and in safety.

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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.

5. ACKNOWLEDGEMENTS

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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 cardiorespilatory 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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