Table 3
Odds ratio (95% confidence interval) of falls in Japanese and Brazilian participants.

Risk factors	Japan ($n = 40$)	p	Brazil ($n = 74$)	p
Age	1.03 (0.873 – 1.22)	0.71	0.972 (0.865 – 1.09)	0.62
BMI	0.961 (0.698 – 1.32)	0.81	1.14 (0.987 – 1.31)	0.07
Waist circumference	0.933 (0.827 – 1.05)	0.25	1.07 (1.018 – 1.13)	0.009
Handgrip strength	0.839 (0.722 – 0.975)	0.02	0.966 (0.904 – 1.03)	0.30
Balance	0.959 (0.902 – 1.02)	0.18	0.984 (0.934 – 1.03)	0.55
On medication	5.05 (0.559 – 45.6)	0.14	1.12 (0.208 – 6.09)	0.89
Hospitalization in the past 6 mo	4.72 (0.387 – 57.6)	0.22	3.00 (0.553 – 16.2)	0.20
Physical activity	0.37 (0.113 – 1.22)	0.10	0.533 (0.188 – 1.51)	0.23

Data are presented as Odds ratio (95% confidence interval).
BMI = body mass index.

strength and waist circumference be used as potential screening tools for falls in Japanese and Brazilian older adults, respectively.

In addition, factors such as ethnicity, eating habits, lifestyle, and social behaviors should also be investigated.[5] However, these factors are difficult to control, and there is uncertainty about the influence of these factors on regional differences in the prevalence of falls between these countries. Therefore, the limitations of our study include the following factors: (1) cross-sectional design; (2) potential bias caused by the selection of physically active individuals; (3) small sample size that limits our observations to a community in each country; and (4) a small set of variables used to identify individuals at risk of falls. In this sense, our pilot study provides evidence that falls may be triggered by distinct factors that differ between Japanese and Brazilian older adults. However, further studies should consider a different sample size and spectrum of variables.

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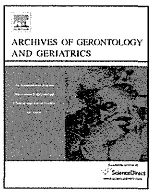

Chronic kidney disease (CKD) is an independent risk factor for long-term care insurance (LTCI) need certification among older Japanese adults: A two-year prospective cohort study

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ABSTRACT

CKD is associated with impairments in health status, physical function, and frailty. The aim of the current prospective cohort study was to determine whether CKD predicted new LTCI need certification among community-dwelling older Japanese adults. This was a prospective cohort study. We analyzed the cohort data from a prospective study, The Japan Multicenter Aging Cohort for Care Prevention (J-MACC). We followed 8063 elderly adults for 2 years, and we analyzed the relationship between CKD and LTCI need. The outcome studied was new certification for LTCI service need during a 2-year period. We measured serum creatinine (the estimated glomerular filtration rate; eGFR), serum albumin, frailty checklist scores, and body mass index. During the 2-year follow-up, 536 subjects (6.6%) were newly certified as needing LTCI services. We stratified the cohort according to eGFR quartile and performed multivariate analyses using an eGFR value of 71.4–83.6 ml/min/1.73 m^2 as a reference. We found that subjects with eGFR values <60.0 ml/min/1.73 m^2 had a significantly elevated risk of LTCI service need (adjusted hazard ratio: 1.44 [95% CI 1.12–1.86]). Our results indicate that CKD is independently associated with new LTCI service need certification and is an important marker of frailty in older adults.

1. Introduction

Frailty in older adults is a serious problem in countries with aging populations, such as Japan. In general, frailty is defined as a vulnerable state that places older adults at high risk of adverse health outcomes, such as falls, hospitalization, and mortality (Wiswell et al., 2001).

Age is a major risk factor for CKD, which is a growing health problem in Japan. The prevalence of CKD in the adult Japanese population is estimated to be 13% (Imai et al., 2009). In addition, the number of patients with end-stage renal disease (ESRD) has increased by approximately 7% per year in Japan (Akiba et al., 2000). CKD is associated with impairments in health status and physical function, as well as frailty (Brogan, Haber, & Kutner, 2000; Kurella et al., 2004; Kurella, Yaffe, Shlipak, Wenger, & Chertow, 2005). CKD is also associated with oxidative stress, chronic inflammation, insulin resistance, vascular calcification, and osteoporosis (Ensrud et al., 2007; Landau et al., 2011; Shanahan, 2005). Furthermore, a decreased creatinine clearance <60 ml/min/1.73 m^2 has been shown to predict incident falls among community-dwelling older women (Gallagher, Rapuri, & Smith, 2007). Thus, CKD poses a considerable medical and public health challenge, particularly in the older population.

Japan implemented a LTCI system in April 2000 to help manage a rapidly aging population. Prior to 2000, long-term care services were provided under a tax-based social welfare system for seniors with limited economic resources and family support (Campbell & Ikegami, 2000). However, since the implementation of LTCI, the services of this program have been provided to elderly adults who are certified as requiring support or care according to their care needs and certification assessment (Tsutsui & Muramatsu, 2005).

The aim of the current prospective cohort study, therefore, was to determine whether CKD was a risk factor for LTCI need among community-dwelling older Japanese adults.

2. Methods

2.1. Subjects

We analyzed the cohort data from a prospective study entitled J-MACC. This cohort study investigated the factors associated with LTCI need in community-dwelling Japanese

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adults aged 65 years or older. We recruited community-dwelling older adults who were independent in terms of the activities of daily living (ADL) in 2009. The exclusion criteria were older adults who were already ADL-dependent and were eligible to receive benefits from LTCI services. The subjects were followed prospectively for 2 years. During the follow-up period, 226 subjects died or moved; thus, we analyzed 8063 elderly adults. This study was conducted in accordance with the guidelines of the Declaration of Helsinki, and the study protocol was reviewed and approved by the Ethics Committee of the Kyoto University Graduate School of Medicine.

2.2. Serum creatinine and albumin

The serum creatinine and albumin levels of the subjects were measured. The estimated glomerular filtration rate (eGFR) was calculated using a formula reported by Matsuo et al. (2009): eGFR ($\text{mL/min}/1.73\ \text{m}^2$) = $194 \times \text{Scr}^{-1.094} \times \text{Age}^{-0.287} \times 0.739$ (if female). This equation originated from the MDRD study group (Coresh, Astor, Greene, Eknoyan, & Levey, 2003) arranged for Japanese individuals, and it is recommended by the Japanese Society of Nephrology. The study cohort was divided into 4 groups according to serum albumin and eGFR quartiles.

2.3. Frailty checklist

The frailty checklist included simple yes/no questions concerning lifestyle (questions 1–5), motor abilities (questions 6–10), nutrition (questions 11–12), oral functions (questions 13–15), seclusion (questions 16–17), forgetfulness (questions 18–20), and emotions (questions 21–25) (Table 1). The total score on the frailty checklist is useful for predicting the risk of being newly certified as needing LTCI services (Coresh et al., 2003). Furthermore, physical exercise is an effective means of improving the total score on the frailty checklist (Imai et al., 2007).

2.4. Body mass index

The patients' height and weight were measured to calculate their body mass index (BMI).

2.5. Outcome measure

The outcome measure was new LTCI service need certification over a 2-year period. The selection process for classifying dependent older adults first involves a questionnaire that evaluates the person's current mental and physical condition (74 items), which is analyzed using a computerized algorithm. A long-term care approval board reaches a final decision based on the algorithm-aided analysis of the questionnaire, a doctor's recommendation, and a home visit report. Individuals who become certified as dependent older adults are subdivided into seven levels (support levels 1 and 2 and care levels 1–5), depending on their conditions. They are provided home and community-based or institutional services according to their care needs. Individuals who are not eligible for long-term care or support care may utilize preventive care services.

2.6. Statistical analysis

The baseline characteristics of the subjects who were certified or non-certified as needing LTCI services were compared. Differences in the demographic variables between the 2 groups were analyzed using Student's *t*-test or a chi-square test. In addition, differences in the demographic variables among the 4 groups stratified by eGFR quartile were examined using an analysis of variance (ANOVA) and a post hoc test. Kaplan-Meier survival curves were calculated for the group newly determined to need LTCI services and were stratified by eGFR quartile. Cox proportional hazards models were used to estimate the hazard ratios (HR) and 95% confidence intervals (CI) of the relationships between

Table 1
The frailty checklist used in Japan.

Domain	Question	Items	Yes	No
Lifestyle	1	Do you ride the bus or train alone?	0	1
	2	Do you buy household goods for everyday use?	0	1
	3	Do you withdraw and deposit savings?	0	1
	4	Do you visit your friends' homes?	0	1
	5	Do you give advice to family and friends?	0	1
Motor abilities	6	Can you climb stairs without holding onto a handrail or the wall?	0	1
	7	Can get up from a chair without grabbing something?	0	1
	8	Are you able to keep walking for about 15 min?	0	1
	9	Have you fallen in the past year?	1	0
	10	Are you very worried about falling?	1	0
Nutrition	11	Have you ever lost more than 2–3 kg of weight in a 6-month period?	1	0
	12	BMI is less than 18.5.	1	0
Oral function	13	I cannot eat hard foods as well as 6 months ago.	1	0
	14	Have you ever choked on tea or soups?	1	0
	15	Are you concerned with being thirsty?	1	0
Seclusion	16	Do you leave your home at least once a week?	0	1
	17	Compared to last year, has the number of times you go out decreased?	1	0
Forgetfulness	18	Are you told that you are forgetful or you always tell me the same thing?	1	0
	19	Do you look up phone numbers and make phone calls yourself?	0	1
	20	Do you sometimes forget the date and month?	1	0
Emotions	21	(In the past 2 weeks) I do not feel fulfillment in my daily life.	1	0
	22	(In the past 2 weeks) The activities I used to enjoy are no longer enjoyable.	1	0
	23	(In the past 2 weeks) The activities I used to carry out with ease have become troublesome.	1	0
	24	(In the past 2 weeks) I do not think I am a useful person.	1	0
	25	(In the past 2 weeks) I feel tired for no reason.	1	0

Table 2
Baseline characteristics of the study subjects in both groups.

	Certified for LTCI requirement ($n = 536$)			Non-certified for LTCI requirement ($n = 7527$)			
	Mean	SD	Min–max	Mean	SD	Min–max	P-Value
Age (years)	80.8	7.4	66–100	76.7	6.5	65–102	<0.001
Gender (female)	332 (61.9%)	4405 (58.5%)	0.043				
BMI (kg/m^2)	22.4	3.5	13.8–35.8	22.8	3.2	12.7–39.8	0.073
Frailty checklist (points)	6.5	4.9	0–23	4.3	4.0	0–24	<0.001
Serum albumin (g/dl)	4.2	0.3	3.2–5.0	4.3	0.3	2.6–5.4	<0.001
eGFR (ml/min/1.73 m^2)	68.5	20.7	22.2–121.3	71.4	17.2	20.3–123.8	<0.001

eGFR quartile and the time to new LTCI service need certification in univariate and multivariate analyses. Multivariate analyses were performed for each covariate and were adjusted for gender, BMI, frailty checklist score, and serum albumin level, factors that are known to be associated with frailty (Levey et al., 2006; Tomata et al., 2011; Yamada, Arai, Sonoda, & Aoyama, 2012). Survival time was defined as the time between enrollment (the date of the baseline measurements) and either the new LTCI service need certification or the end of the follow-up period (March 31, 2011). The data were analyzed using PASW (Windows version 18.0, SPSS, Inc., Chicago, IL). A P value <0.05 was considered statistically significant for all the analyses.

3. Results

During the 2-year follow-up, 536 subjects (6.6%) became newly certified as needing LTCI services (Table 2). Those who were certified for LTCI need were significantly older (80.8 ± 7.4 vs. 76.7 ± 6.5, $P < 0.001$) and had higher frailty checklist scores (6.5 ± 4.9 vs. 4.3 ± 4.0, $P < 0.001$), lower serum albumin levels (4.2 ± 0.3 vs. 4.3 ± 0.3, $P < 0.001$), and lower eGFR values (68.5 ± 20.7 vs. 71.4 ± 17.2, $P < 0.001$) than those who were not certified. More women than men became certified in this cohort (female: 61.6% vs. 58.5%, $P = 0.043$). However, the BMIs were not different between the two groups ($P = 0.073$) (Table 2). We also examined whether eGFR was associated with BMI, frailty checklist score, or serum albumin level. We found that the subjects with eGFR < 60.0 ml/min/1.73 m^2 were significantly older and had lower BMIs, higher frailty checklist scores, and lower serum albumin levels ($P < 0.05$) (Table 3).

Next, we examined the relationship between each variable and new LTCI need certification. The subjects with BMIs <20.5 exhibited a significantly elevated risk of LTCI service need according to multivariate analyses using a BMI of 22.7–24.7 as the reference (adjusted hazard ratio: 1.41 [95% CI 1.11–1.78]) (Table 4). The mean BMI was 22.7 ± 3.3, with a range from 12.7 to 39.8; 1975 participants (24.5%) had BMIs <20.5. The subjects with frailty checklist scores >6 had a significantly elevated risk of LTCI service need according to multivariate analyses using frailty checklist scores <2 as the reference (adjusted hazard ratio: 2.24 [95% CI 1.73–2.90]) (Table 4). The mean frailty checklist score was 4.5 ± 4.1, with a range from 0 to 24; 2042 participants (25.3%) had frailty checklist scores >6. Participants with serum albumin levels <4.1 g/dl tended to exhibit an elevated risk of LTCI service need according to multivariate analyses using a serum albumin level >4.4 g/dl as the reference (adjusted hazard ratio: 1.25 [95% CI 0.97–1.62]). However, the univariate analysis indicated that subjects with serum albumin levels <4.1 g/dl had an elevated risk of LTCI service need (Table 4). The mean serum albumin level was 4.2 ± 0.3 g/dl, with a range from 2.6 to 5.4; 1722 participants (21.3%) had serum albumin levels <4.1 g/dl.

Fig. 1 shows the Kaplan-Meier survival curves according to new LTCI service need certification, with the subjects stratified into 4 groups according to eGFR quartile. Individuals with eGFR values <60.0 ml/min/1.73 m^2 had a significantly elevated risk of LTCI service need according to multivariate analyses using an eGFR value of 71.4–83.6 ml/min/1.73 m^2 as the reference (adjusted hazard ratio: 1.44 [95% CI 1.12–1.86]) (Table 4). The mean eGFR was 71.2 ± 17.4 ml/min/1.73 m^2, with a range from 20.3 to 123.8 ml/min/1.73 m^2; 1963 participants (24.3%) had eGFR values <60 ml/min/1.73 m^2.

4. Discussion

In this study, we found that approximately 25% of adults aged 65 years or over had eGFR values <60 ml/min/1.73 m^2, which indicates that CKD is common among older Japanese adults. The multivariate analyses demonstrated eGFR values <60.0 ml/min/1.73 m^2 were independently associated with new certifications for LTCI service need. Thus, our data indicate that CKD is a critical marker of frailty in older adults.

According to the multivariate analyses, lower BMIs (less than 20.5), and higher frailty checklist scores (more than 6) were associated with certification for LTCI service need. These results are consistent with those of previous studies (Levey et al., 2006; Tomata et al., 2011; Yamada et al., 2012), which revealed that the subjects with the lowest BMIs had an elevated risk of requiring care and that frailty checklist scores were strongly associated with new LTCI service need certifications (Levey et al., 2006). Thus, it is important to assess nutrition, cognitive function, mood, and ADL for care prevention, and the frailty checklist includes these items.

In terms of nutrition, however, our study failed to demonstrate that serum albumin levels were significantly associated with new LTCI service need certification after adjusting for other frailty-related factors, although the univariate analysis demonstrated that

Table 3
Demographic differences according to eGFR quartile.

	eGFR (ml/min/1.73 m^2)									
	Q1: <60.0		Q2: 60.0–71.3		Q3: 71.4–83.6		Q4: >83.6		P-value	Post hoc
Gender (female)	1122 (57.2%)		1153 (54.2%)		1066 (54.2%)		1429 (71.2%)		<0.001	Q2,3 < Q1 < Q4
BMI (kg/m^2)	23.1	3.3	22.7	3.2	22.9	3.1	22.4	3.4	<0.001	Q1 > Q4 > Q2,3
Frailty checklist (points)	5.2	4.6	4.0	3.9	3.2	3.6	3.9	3.8	<0.001	Q1 > Q2 > Q4 > Q3
Serum albumin (g/dl)	4.11	0.27	4.16	0.26	4.21	0.25	4.21	0.26	<0.001	Q1 < Q2 < Q3,4

Table 4
Predictors of new LTCI service need certification during a 2-year follow-up period.

		Certified for LTCI requirement		Non-certified for LTCI requirement		Univariate analysis			Multivariate analysis		
						HR	95%CI	P-value	HR	95%CI	P-value
Gender	Female	332	7.0%	4405	93.0%	ref			ref		
	Male	204	6.1%	3122	93.9%	0.88	0.76–1.03	0.11	0.98	0.83–1.17	0.86
BMI	Q1: <20.5	179	9.1%	1796	90.9%	1.53	1.21–1.92	<0.01	1.41	1.11–1.79	<0.01
	Q2: 20.5–22.6	120	5.9%	1915	94.1%	1.00	0.78–1.29	1.00	1.01	0.78–1.30	0.92
	Q3: 22.7–24.7	121	6.0%	1892	94.0%	ref			ref	-	
	Q4: >24.7	140	6.9%	1900	93.1%	1.13	0.88–1.44	0.35	1.09	0.85–1.39	0.51
Frailty checklist	Q1: <2	91	4.1%	2106	95.9%	ref			ref		
	Q2: 2–3	105	5.5%	1802	94.5%	1.36	1.03–1.80	0.03	1.30	1.30–1.73	0.13
	Q3: 4–6	117	6.1%	1800	93.9%	1.51	1.15–1.99	<0.01	1.41	1.06–1.86	0.01
	Q4: >6	247	12.1%	1795	87.9%	3.04	2.38–3.87	<0.01	2.63	2.05–3.39	<0.01
Serum albumin	Q1: <4.1	167	9.7%	1555	90.3%	1.75	1.36–2.24	<0.01	1.36	1.05–1.75	0.02
	Q2: 4.1–4.2	150	6.7%	2076	93.3%	1.19	0.92–1.53	0.18	1.04	0.81–1.35	0.75
	Q3: 4.3–4.4	140	6.0%	2200	94.0%	1.09	0.84–1.40	0.52	1.01	0.78–1.31	0.93
	Q4: >4.4	101	5.6%	1694	94.4%	ref			ref		
eGFR	Q1: <60.0	191	9.7%	1772	90.3%	1.99	1.55–2.54	<0.01	1.63	1.26–2.09	<0.01
	Q2: 60.0–71.3	142	6.7%	1983	93.3%	1.37	1.06–1.77	0.02	1.25	0.96–1.62	0.10
	Q3: 71.4–83.6	97	4.9%	1871	95.1%	ref			ref		
	Q4: >83.6	128	6.4%	1879	93.6%	1.29	0.99–1.68	0.06	1.17	0.89–1.53	0.26

The multivariate analysis was adjusted for gender, BMI, frailty checklist score, and serum albumin level.

a significantly larger number of subjects in the first quartile were certified as needing LTCI. Furthermore, previous studies have indicated that lower serum albumin levels are associated with future functional decline in older adults (Kalyani et al., 2012; Kane, Shamliyan, Talley, & Pacala, 2012). We assume that this result was caused by our study lacking sufficient power to demonstrate a contribution of low serum albumin to new LTCI service need certifications and by the small number of subjects with malnutrition in this cohort. Nonetheless, CKD was found to be significantly associated with new LTCI service need certification. Therefore, it should be noted that CKD may independently predict new LTCI service need certification in older adults.

We found that the subjects with the highest eGFR values (4th quartile) tended to have a higher risk of new LTCI service need certification, lower BMIs, and higher checklist scores than those in the 3rd quartile, although this difference was not statistically significant. Because eGFR is calculated using serum creatinine levels, a higher eGFR may indicate lower muscle mass, especially in older adults. Therefore, it should be noted that older adults with elevated eGFR values may be frail. Further research is required to address the role of eGFR in frailty.

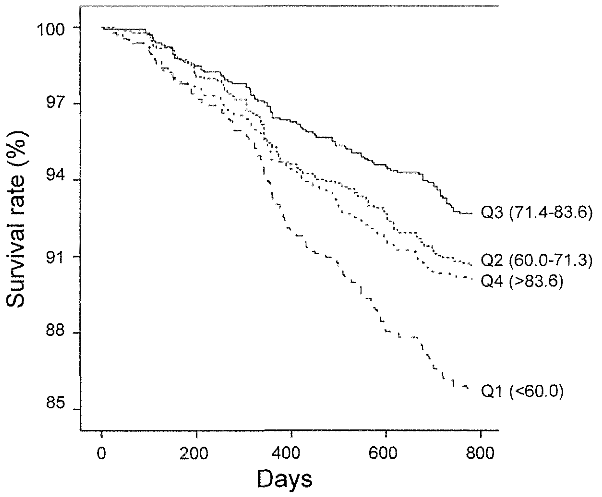

Fig. 1. Kaplan-Meier survival curves for new LTCI service need are shown for 4 groups according to eGFR quartile.

Malnutrition is known to be associated with frailty. Several studies have suggested that vitamin D deficiencies are common among patients with CKD (Reuben et al., 2002; Zuliani et al., 2001). Both vitamin D2 and D3 are first converted to 25-hydroxyvitamin D by hepatic vitamin D-25-hydroxylase and are then converted to the active form, 1,25-hydroxyvitamin D, by renal 1α-hydroxylase (Zuliani et al., 2001). Reduced activation of vitamin D has been associated with the development of hypertension, left ventricular hypertrophy, heart failure, and vascular calcification (Holick, 2007). In addition, vitamin D deficiency has been associated with sarcopenia, falls, fractures, and dementia (Bischoff-Ferrari, 2012; Chonchol, Kendrick, & Targher, 2011; Cozzolino & Ronco, 2011). Therefore, we hypothesized that CKD was a risk factor for new LTCI service need certification.

Two limitations of this study warrant mention. First, we did not collect information about the subjects' comorbidities. Therefore, the effects of comorbidities on the risk of new certifications for LTCI service need remain unclear. Second, the study participants may have had a greater motivation and interest in health issues than the non-participants. Therefore, it is possible that the non-participants had a higher prevalence of CKD and frailty.

In conclusion, this is the first study to demonstrate that CKD is independently associated with new certifications for LTCI service need. In addition, a relatively high percentage of the subjects had moderate to severe CKD (eGFR <60 ml/min/1.73 m^2). Intervention studies are needed to explore whether treating CKD may delay or prevent new certifications for LTCI service need among older adults.

Conflicts of interest

None of the authors have conflicts of interest or financial disclosures.

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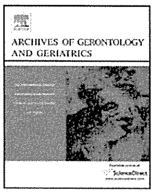
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Effect of the muscle coactivation during quiet standing on dynamic postural control in older adults

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ABSTRACT

Recently, several studies have reported that muscle coactivation during static postural control increases with aging. Although greater muscle coactivation during quiet standing enhances joint stability, it may reduce dynamic postural control. The purpose of this study was to investigate the effect of muscle coactivation during quiet standing on dynamic postural control. Seventy older adults (81.1 ± 7.2 years) participated in this study. Static postural control was evaluated by postural sway during quiet standing, whereas dynamic postural control was evaluated by the functional reach and functional stability boundary tests. Electromyography of the soleus (SOL) and tibialis anterior (TA) was recorded during quiet standing, then coactivation was evaluated using the co-contraction index (CI). We used multiple regression analysis to identify the effect of muscle coactivation during standing on each dynamic postural control variable using age, body mass index (BMI), gender, timed up and go (TUG) tests, postural sway area and CI during quiet standing as independent variables. TUG tests were added to the model to evaluate the effect of functional mobility on dynamic postural control with a fixed base. The multiple regression analysis revealed that CI during standing was significantly related to all of the dynamic postural control tasks. The functional reach distance was significantly associated with CI during standing, age and TUG ($p < 0.05$). The functional stability boundary for forward and backward were associated only with CI during standing ($p < 0.05$). This study revealed that muscle coactivation during quiet standing is independently associated with dynamic postural control abilities.

1. Introduction

Both static and dynamic postural controls are fundamental components of human activity. Aging has been associated with deterioration in postural control, manifesting itself by an increase in postural sway as static postural control (Era & Heikkinen, 1985; Shumway-Cook, Baldwin, Polissar, & Gruber, 1997) or a decrease in the voluntary movement capacity of the body's center of gravity (COG) as dynamic postural control (Duncan, Studenski, Chandler, & Prescott, 1992; Slobounov, Moss, Slobounova, & Newell, 1998). Deterioration in these functions leads to a higher risk of falling, which in turn may increase the number of bedridden persons (Duncan et al., 1992; Lord, Clark, & Webster, 1991).

Several studies have reported age-associated increases in muscle coactivation during dynamic movements (*i.e.* walking and stair climbing) (Hortobagyi et al., 2009; Schmitz, Silder, Heiderscheit, Mahoney, & Thelen, 2008) and postural control (Allum, Carpenter, Honegger, Adkin, & Bloem, 2002; Ge, 1998; Manchester, Woollacott, Zederbauer-Hylton, & Marin, 1989; Melzer, Benjuya, & Kaplanski, 2001; Nagai, Yamada, Uemura, Yamada, et al., 2011; Tang & Woollacott, 1998; Tucker, Kavanagh, Barrett, & Morrison, 2008). Increased muscle coactivation in older adults is often described as a compensatory mechanism to increase joint stiffness that thereby enhances joint and postural stability (Manchester et al., 1989; Melzer et al., 2001; Tucker et al., 2008). On the other hand, some researchers have pointed out negative effects of coactivation on postural control and movement, observing that excessive muscle coactivation increases postural rigidity and might restrict dynamic postural control. A rigid posture induced by strong muscle coactivation reduces flexibility (Ge, 1998; Tucker et al., 2008) and may compromise the ability to adjust to unexpected perturbations (Allum et al., 2002). This could increase the risk of falling (Hortobagyi et al., 2009).

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Previously, we demonstrated that muscle coactivation at the ankle joint during quiet standing and dynamic postural control in older adults is greater than those of young adults. Additionally, the decline of dynamic postural control ability has been correlated with increased muscle coactivation during task performance (Nagai, Yamada, Uemura, Yamada, et al., 2011; Nagai et al., 2012). Hsiao-Wecksler et al. (2003) have reported that sway of the center of pressure (COP) during quiet standing relates to dynamic postural control ability. In upright postural control, active COP movement during dynamic postural control starts generally from quiet standing. Hence, muscle coactivation during quiet standing can also influence dynamic postural control similarly to, but not identically with, muscle coactivation during dynamic postural control tasks. However, little has been reported on the effect of muscle coactivation during quiet standing on dynamic postural control. Clarification of this relationship would be helpful to developing optimal rehabilitation strategies that improve dynamic postural control ability in older adults. The purpose of this study was to investigate the effect of muscle coactivation during quiet standing on dynamic postural control.

2. Materials and methods

2.1. Participants

Resident and community dwelling older adults were recruited using advertising literature and oral announcements by research staff and staff members in nursing homes. Seventy older adults (56 residents, 14 community dwellers; 11 males, 59 females; mean age = 81.1 ± 7.2 years) participated in this study (Table 1). Because of gender proportion in the nursing home residents, the number of male participants was relatively small. Subjects were excluded if they had neurological impairment (stroke, Parkinson's disease, paresis of the lower limbs), severe cardiovascular disease, severe cognitive impairment (Rapid Dementia Screening Test score of four points or less (Kalbe, Calabrese, Schwalen, & Kessler, 2003)), persistent joint pain, or musculoskeletal impairment. Each subject gave informed consent indicating their agreement with the study protocol. This research was approved by the Ethical Review Board of Kyoto University Graduate School of Medicine, Kyoto, Japan.

2.2. Testing procedures and protocol

To measure static postural control ability, which reflects movement of the COG in a quiet situation (Era & Heikkinen, 1985), we performed tests for postural sway during quiet standing. To measure dynamic postural control ability involving active COG movement capacity in the base of support (Slobounov et al., 1998), we carried out functional reach and functional stability boundary tasks.

Table 1
Characteristics of subjects (mean ± SD).

Characteristic	$n = 70$
Physical characteristics	
Age, mean ± SD (range)	81.1 ± 7.2
Female (%)	84.3
Height (cm)	151.4 ± 6.4
Weight (kg)	52.2 ± 7.0
BMI	22.9 ± 3.5
Physical performance	
Postural sway area (cm^2)	1.7 ± 1.03
Functional reach (cm)	20.9 ± 7.9
Functional stability boundary (forward) (%)	25.5 ± 9.7
Functional stability boundary (backward) (%)	18.4 ± 4.6
Walking speed (m/s)	0.9 ± 0.3
TUG test (s)	9.7 ± 5.2

2.2.1. Postural sway

Postural sway during quiet standing was measured with a force plate (Kistler 9286 force platform, Kistler Instruments Inc., Amherst, NY). Signals were sampled at 20 Hz and processed by a low pass filter (6 Hz cut off frequency). Subjects were instructed to stand with their feet together as symmetrically as possible. Quiet standing balance was registered for a period of 10 s, from which the root mean square (RMS) area of the COP was calculated. The intraclass correlation coefficient ($ICC_{1,1}$), calculated from two immediately repeated tests, for the RMS area was 0.72. Electromyographic (EMG) measurements of the SOL and TA were collected for three seconds, starting just after the standing posture stabilized. The EMG data recording period of three seconds is widely used for tasks with isometric muscle contraction. The testing reliability was confirmed previously (Nagai, Yamada, Uemura, Yamada, et al., 2011).

2.2.2. Functional reach

The functional reach test (Duncan, Weiner, Chandler, & Studenski, 1990; Duncan et al., 1992) measures the distance that subjects are able to reach forward while maintaining a fixed base. The position of the fingertip is determined with the shoulder of the subject flexed at 90° along a wall. The subjects then were instructed to reach as far forward as possible without moving their feet, thus moving the COG forward over a fixed base, and keep their position for 3 s. Functional reach was defined as the difference between arm's length and maximal forward reach. After a trial, the test was performed once.

2.2.3. Functional stability boundary

Functional stability boundary tasks were performed on the force plate (Slobounov et al., 1998). The subjects were instructed to stand with their heels positioned on a line 10 cm anterior to the posterior edge of the plate. The subjects were instructed to stand still for 5 s and then to shift their body weight first toward their toes and then toward their heels over the largest possible amplitude. They were further instructed to maintain full contact between their feet and the plate (avoiding toes off or heels off). For each direction (forward and backward), the subject maintained his/her posture for 3 s, from which the averaged COP displacement from the initial position was calculated. The COP displacement for each subject was normalized individually to the length of that subject's foot. After a trial, the test was performed once. The $ICC_{1,1}$ for the functional stability boundary tests were 0.95 for forward and 0.94 for backward in this study.

2.2.4. Additional physical performance test

The 10 m walking test and TUG test (Shumway-Cook, Brauer, & Woollacott, 2000) were performed without EMG monitoring. Subjects were asked to perform walking trials at their preferred speed. The walking speed (m/s) was calculated from the 10 m walking time.

2.3. EMG recording

EMG data were collected by sampling at 1500 Hz using the Telemyo 2400 (Noraxon USA Inc., Scottsdale, AZ). The skin of the dominant leg was shaved over the fibular head, TA, and SOL (Melzer et al., 2001) and then washed with alcohol. Bipolar surface electrodes (Ambu, Blue sensor M, Denmark) with a 2.0 cm inter-electrode distance were placed on the skin around the probable motor point of the muscles (Hermens). The ground electrode was affixed to the skin over the fibular head of the dominant leg.

EMG activity was recorded from the SOL and TA while the subjects were performing maximal voluntary contractions (MVCs). The MVC of the SOL was obtained during maximal isometric plantar flexion, and maximal TA activation was recorded during maximal isometric dorsiflexion of the ankle at 90° (anatomically neutral position). Strong verbal encouragement was given during every contraction to promote maximal effort. The EMG data from the MVCs were used to normalize the EMG amplitude (%MVC) during the postural tasks.

2.4. Muscle coactivation analysis

The original raw EMG signal during quiet standing was band-pass filtered at 20–500 Hz. We computed the RMS amplitude of the signal using a 50 ms window. The EMG of each muscle was then expressed as a percentage of the EMG value during the MVC.

To evaluate the relative level of co-contraction of the TA and SOL muscles, the CI was calculated using the method of Falconer and Winter (1985). Specifically, the following equation was used:

$$\mathrm{CI} = \frac{2I_{\mathrm{ant}}}{I_{\mathrm{Total}}} \times 100\%$$

I_{ant} is the area of the total antagonistic activity calculated by

$$I_{\mathrm{ant}} = \int_{t_1}^{t_2} \mathrm{EMG}_{\mathrm{TA}}(t)\mathrm{d}t + \int_{t_2}^{t_3} \mathrm{EMG}_{\mathrm{SOL}}(t)\mathrm{d}t$$

where t_1 to t_2 denotes the period during which the TA EMG is less than the SOL EMG and t_2–t_3 donates the period during which the SOL EMG is less than the TA EMG.

I_{total} is the integral of the sum of TA and SOL EMG during performance of the task calculated by

$$I_{\mathrm{total}} = \int_{t_1}^{t_3} [\mathrm{EMG}_{\mathrm{agon}} + \mathrm{EMG}_{\mathrm{ant}}](t)\mathrm{d}t$$

The test–retest reliability of the EMG measurement for standing without relocating the electrode was confirmed previously ($\mathrm{ICC}_{1.1} = 0.87$) (Nagai, Yamada, Uemura, Yamada, et al., 2011).

2.5. Statistics

SPSS (Windows version 12.0, SPSS, Inc., Chicago, IL) software was used for the data analysis. The relationship between coactivation during quiet standing and each postural control variable was analyzed by Spearman rank correlation. We used multiple regression analysis using the forced entry method to identify the effect of muscle coactivation during standing on dynamic postural control. The dependent variables were each dynamic postural control variable (reach distance during functional reach and COP displacement during functional stability boundary for forward and backward), with age, BMI, gender, TUG time, postural sway area and CI during quiet standing as independent variables. BMI and gender were also included as independent variables to control the effect of physical attributes and gender differences. Statistical significance was set at $p < 0.05$.

3. Results

The characteristics and physical performance of subjects are shown in Table 1. The CI during quiet standing was 51.2 ± 22.8%, and the muscle activities in TA and SOL were 14.1 ± 12.5%MVC and 25.5 ± 17.6%MVC, respectively.

Spearman rank correlation revealed a significant correlation between postural control and CI during quiet standing (Fig. 1, $p < 0.05$). The sway area during standing ($\rho = 0.278$, $p = 0.023$), functional reach ($\rho = -0.550$, $p < 0.001$) and functional stability boundary for forward ($\rho = -0.437$, $p < 0.001$) and backward ($\rho = -0.335$, $p = 0.006$) significantly correlated with CI during standing.

The multiple regression analysis revealed that CI during standing was significantly related to all of the dynamic postural control tasks (Table 2). The functional reach distance was significantly associated with CI during standing ($\beta = -0.385$, $p = 0.001$), age ($\beta = -0.250$, $p = 0.046$) and TUG ($\beta = -0.273$, $p = 0.021$). The functional stability boundary for forward was significantly associated only with CI during standing ($\beta = -0.424$,

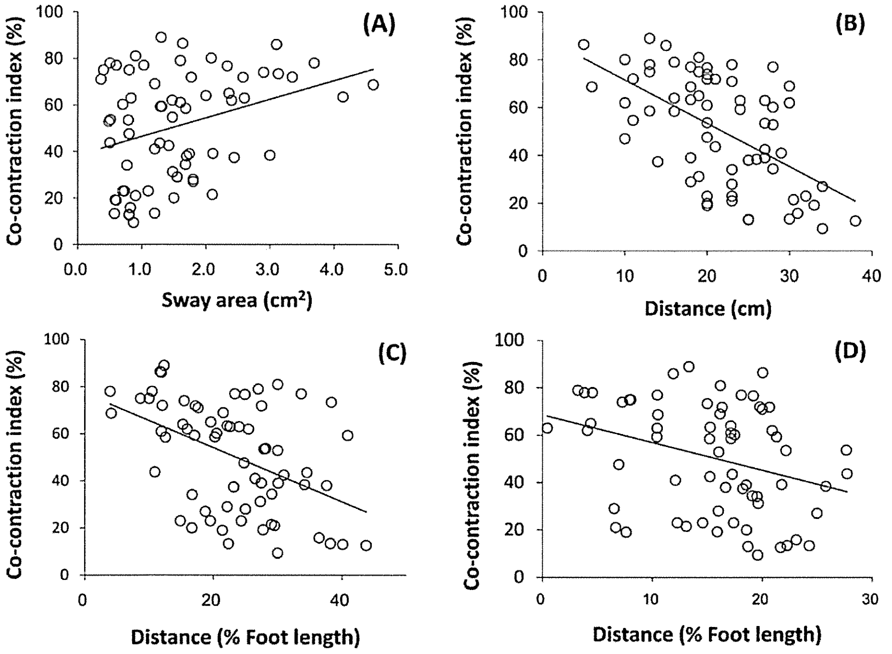

Fig. 1. Correlations between postural control and CI during quiet standing using Spearman rank correlation. Co-contraction during quiet standing is significantly correlated to all tasks. (A) Sway area during standing ($\rho = 0.278$, $p = 0.023$), (B) functional reach ($\rho = -0.550$, $p < 0.001$), (C) functional stability boundary (forward) ($\rho = -0.437$, $p < 0.001$), and (D) functional stability boundary (backward) ($\rho = -0.335$, $p = 0.006$).

Table 2
Multiple linear regression models using the forced entry method associated with dynamic postural control abilities.

Dependent variables	Independent variables	R^2	B	Standardized error (SE)	β	p value
Functional reach	Age	0.483	−0.235	0.115	−0.250	0.046
	BMI		−0.235	0.238	−0.035	0.753
	Gender		2.438	1.876	0.131	0.201
	CI during standing (%)		−0.104	0.030	−0.385	0.001
	Postural sway area (cm^2)		0.038	0.782	0.006	0.808
	TUG (s)		−0.332	0.140	−0.273	0.021
Functional stability boundary (forward)	Age	0.319	−0.180	0.188	−0.138	0.341
	BMI		0.292	0.383	0.092	0.449
	Gender		1.930	3.018	0.075	0.525
	CI during standing (%)		−0.159	0.049	−0.424	0.002
	Postural sway area (cm^2)		−0.426	1.258	−0.047	0.736
	TUG (s)		−0.168	0.234	−0.098	0.475
Functional stability boundary (backward)	Age	0.170	−0.099	0.154	−0.102	0.522
	BMI		0.345	0.313	0.146	0.276
	Gender		1.512	2.468	0.080	0.543
	CI during standing (%)		−0.092	0.040	−0.332	0.025
	Postural sway area (cm^2)		−0.619	1.029	−0.092	0.550
	TUG (s)		0.165	0.191	0.129	0.393

R^2: multiple correlation coefficient.
B: partial regression coefficient.
β: standardized partial regression coefficient.

$p = 0.002$). The functional stability boundary for backward was also significantly associated only with CI during standing ($\beta = -0.332$, $p = 0.025$).

4. Discussion

The present study investigated the relationship between muscle coactivation at the ankle joint under quiet standing and dynamic postural control abilities. The study yielded two major findings: (1) muscle coactivation at the ankle joint during quiet standing was significantly correlated with static and dynamic postural control ability and (2) muscle coactivation during quiet standing was independently associated with dynamic postural control abilities. This is the first study to measure the effect of coactivation during quiet standing on dynamic postural control ability.

In the present study, muscle coactivation during quiet standing was significantly correlated with postural sway. Melzer et al. (2001) showed higher coactivation in older adults than in young adults during quiet standing, while Manchester et al. (1989) demonstrated greater coactivation of antagonists in older adults under perturbed conditions. These researchers described the greater coactivation of antagonists with resultant ankle joint stiffness as a strategy to maintain postural stability. Older adults who cannot keep their COP within a narrow range may utilize a high muscle coactivation strategy during quiet standing. Increased joint stiffness by higher muscular coactivation may compensate for the many neuromotor impairments associated with aging, including reduced muscle strength (Hortobagyi et al., 1995), reduced proportion of fast muscle fibers (Larsson, Grimby, & Karlsson, 1979), miscued limb positioning (Skinner, Barrack, & Cook, 1984), and fear of falling (Nagai, Yamada, Uemura, Tanaka, 2011; Okada, Hirakawa, Takada, & Kinoshita, 2001).

Our results suggest that the higher muscle coactivation during quiet standing exerts a deleterious effect on dynamic postural control. The higher coactivation has often been interpreted as a positive postural control strategy. Hortobagyi et al. reported increased coactivation of antagonistic muscles during stair descending in older adults compared with young adults (Hortobagyi & DeVita, 2000), which they interpreted as an indication that the older adults had increased muscle coactivation to stiffen the joints of their lower limbs. Chambers and Cham reported that the subjects who walked with higher ankle muscle co-contraction were predisposed to experience less severe slips when encountering an unexpected slippery floor (Hasan et al., 1996). Increased muscle coactivation may be a necessary adaptation to compensate for the poor postural control accompanied by healthy aging. However, some researchers have pointed out negative effects of coactivation on postural control and movement, observing that excessive muscle coactivation increases postural rigidity (Tang & Woollacott, 1998; Wu, 2008). Carolan and Pereira reported that strong coactivation of agonist and antagonist muscles could reduce the performance of agonist muscles in single joint movement (Carolan & Cafarelli, 1992; Pereira & Goncalves, 2010). Mian, Thom, Ardigo, Narici, and Minetti (2006) reported that higher muscle coactivation increased the energetic cost of transport. Excessive muscle coactivation might increase the risk of falling (Hortobagyi et al., 2009). A rigid posture induced by strong muscle coactivation reduces the degrees of freedom in the postural control system (Tucker et al., 2008), and might compromise the execution of voluntary or compensatory responses (Allum et al., 2002; Wu, 2008). These studies indicated that greater coactivation possibly inhibits smooth joint motion and restricts dynamic performance. Additionally, several researchers have demonstrated the relationship between quiet standing and dynamic postural control ability, and have reported that an individual's dynamic postural control may be predicted by COP movement during quiet stance (Hsiao-Wecksler et al., 2003; Lauk, Chow, Pavlik, & Collins, 1998). They also concluded that the postural control system uses the same neuromuscular control mechanisms during quiet standing and dynamic postural control. Therefore, our observation of the negative effect of coactivation during quiet standing on dynamic postural control indicates that the restriction of the flexibility in the ankle joint caused by higher muscle coactivation reduces voluntary movement of the COP during dynamic postural control.

In clinical settings, muscle coactivation during quiet standing may be a useful predictor for the potential of dynamic postural control. When a rehabilitation therapist prescribes balance training for older adults with deteriorated dynamic postural control, efforts to decrease muscle coactivation during quiet standing might be one strategic option.

Limitations of our study include that our study data did not clarify the relationship between muscle coactivation and joint kinematics. In addition, our study provided no information on a postural strategy for the knee or hip joint because it focused on the ankle joint. Second, CI during quiet standing had a large standard deviation because of the variety of coactivation strategies in older adults. As a result, the correlation coefficients between CI and each postural control task were not very high. We therefore cannot provide conclusive evidence for a relationship between coactivation during quiet standing and dynamic postural control. Further studies are needed to examine the effects of muscle coactivation in other joints on dynamic postural control in older adults.

5. Conclusion

This study revealed that muscle coactivation during quiet standing was inversely and significantly associated with dynamic postural control abilities. This result, together with the previous report showing negative correlation between dynamic postural control ability and muscle coactivation during corresponding tasks, suggests that greater muscle coactivation exerts a deleterious effect on dynamic postural control.

Conflicts of interest

None declared.

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Importance of Physical Performance and Quality of Life for Self-Rated Health in Older Japanese Women

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ABSTRACT. Our study aimed to investigate the physical performance and quality of life (QOL) as associated factors with self-rated health (SRH). Japanese community-dwelling women aged 65 years or more ($n = 51$; mean age $= 75.3 \pm 6.0$) answered a questionnaire regarding socio-demographic information, SRH, QOL by the Short Form-8, and performed the physical tests, such as Timed Up and Go, Functional Reach (FR), One Leg Stand (OLS), Five Chair Stands (CS), and hand grip strength (HGS). Smoking ($p = 0.04$), more medical consultations ($p = 0.03$), and more number of medications ($p = 0.001$) were significantly associated with poor self-assessment of their health. Moreover, those who assessed their health condition as not so good to bad condition had lower performance in FR ($p = 0.02$), HGS ($p = 0.04$), OLS ($p = 0.05$), and CS ($p = 0.02$), and poorer QOL condition in general health ($p < 0.01$), bodily pain ($p = 0.02$), and vitality ($p = 0.03$) in comparison with the other SRH groups (good and/or normal). Therefore, we encouraged the use of the SRH assessment and the interpretation of its results based on the present findings such as associating the SRH of older women with their physical performance and QOL.

KEYWORDS. Self-rated health, physical performance, quality of life, older women

INTRODUCTION

Since the World Health Organization defined health as more than the absence of illness, emphasizing the subjective ratings of health, mental well-being, and social relations, the subjective health has become an important issue in medical research and a relevant indicator of therapeutic success in clinical treatment (Burstrom & Fredlund, 2001; DeSalvo, Bloser, & Reynolds, 2006; Quesnel–Valleé, 2007; Sen, 2002). Even in the studies developed several years ago, the subjective rating of

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health was considered as relevant as the objective medical status in older adults (Maddox & Douglass, 1973; Murray & Chen, 1992).

One of the subjective assessment methods of health status is the self-rated health (SRH), a single-item question in which individuals are asked to rate their own health condition. The validity of SRH has been confirmed in several studies to be predictive for mortality in different regions and in different age groups (Cesari et al., 2008; Ford, Spallek, & Dobson, 2008; Idler & Benyamini, 1997; Jylha, Guralnik, Ferrucci, Jokela, & Heikkinen, 1998; Larsson, Hemmingsson, Allebeck, & Lundberg, 2002; Okamoto, Momose, Fujino, & Osawa, 2008; Singh-Manoux et al., 2007). Thus, it is an important research tool, allowing a simple question to monitor population's health.

The SRH is the result of an interaction of specific health problems, general physical functioning, and health behaviors; and the meaning of SRH may vary among the individuals, especially in older adults who have different life history, culture, biopsychosocial conditions (Gunzelmann, Hinz, & Brähler, 2006; Helmer, Barberger-Gateau, Letenneur, & Dartigues, 1999; Idler & Benyamini, 1997; Idler, Kasl, & Lemke, 1990).

Considering this, it is important to determine as to which factors are associated with SRH in order to interpret the data of each population; particularly in older adults that are a growing demand around the world, and in Japan, which is considered an aged society with the highest proportion of elderly (Statistic Bureau Japan, 2010), representing 23.1% of its total population in 2011 (Statistics Bureau of the Ministry of Internal Affairs and Communications, 2011). Therefore, our study aimed to investigate as to which factors, such as physical performance and quality of life (QOL), are associated with SRH in older Japanese women. We hypothesized that those women who evaluate their health as good health condition may have a better physical performance and QOL than those who assess their health condition as not so good to bad condition.

MATERIALS AND METHODS

Study and Subjects

This study had a cross-sectional design. The subjects were community-dwelling women aged 65 years or more ($n = 51$) recruited by (a) a national university through local press, requesting healthy older women to participate in the research and (b) community centers in Kyoto, Japan. The data collection was performed from March 2011 to March 2012. The inclusion criteria were living in the community, aged 65 years or older, being able to respond to the questionnaire, and being able to perform the physical tests. The exclusion criteria were difficult to communicate as measured by the Functional Assessment Staging of Alzheimer's Disease (FAST); those in the FAST stage seven were excluded from the research that indicated severe Alzheimer's disease and loss of most speaking ability and severe and progressive physical losses (Reisberg, 1988).

The study protocol was approved by the Kyoto University Graduate School of Medicine Ethics Committee (E-1245, 2011). All participants were informed of the purpose and procedures of the study and a written consent was obtained.

Assessments

The participants answered a questionnaire about (a) socio-demographic information, such as age, educational level, living structure, current work, financial satisfaction, frequency that they go out home, physical activity practice frequency (characterized by moderate walking, gymnastics, resistance training, yoga, and other activities), use of tobacco, alcohol consumption, medical consultation frequency and hospitalization history (in the last six months), and medications; (b) the SRH by the unique question "In general, how would you say your current health is?" and the answers in a three-point Likert scale with the following options: (1) Very good to good health condition (henceforward, *good*); (2) Normal health condition; (3) Not so good to bad health condition (henceforward, *bad*); and (c) the QOL assessment by the Short Form-8 items (SF-8) that is an abbreviated version of the SF-36 and consisted of eight questions about the general health, physical functioning, role physical, bodily pain, vitality, social functioning, mental health, and role emotional. A higher score in SF-8 means a better QOL.

Additionally, we performed the physical tests that included the Timed Up and Go (TUG), Functional Reach (FR), One Leg Stand (OLS), Five Chair Stands (CS) and hand grip strength (HGS). In the TUG test, we measured the time that the subject spent to stand up from a back rest chair, walk three meters, turn around, walk back, and sit down again. The FR test measured the difference, in centimeters, between arm's length and maximal forward reach, using a fixed base of support. In the OLS, the subjects were asked to pick up one leg and hold with hip in neutral and knee flexed to 90 degrees with arms crossed and maintain standing. The time was measured until the legs touch each other, foot touches down, or arms move from start position, not trespassing 30 seconds. In the CS, the subjects were asked to complete five times sit to stands as quickly as possible without upper extremity assistance. The time taken to complete the fifth sit to stands was recorded. And, finally, the HGS was tested with a standard hand grip dynamometer (Smedlay's Dynamo Meter, TTM, Tokyo, Japan). The participant was asked to stand up and hold the dynamometer with arms parallel to the body; the HGS was measured for both hands once on each side, and the higher value was used to characterize the maximum muscle strength of the participant. HGS was expressed in kg. These tests were selected due to its intrinsic characteristics of mainly assessing walk ability, flexibility/balance and muscle power/strength, among others; and were then ordered considering these factors. A resting time of 2 min was provided between each assessment and a longer time if the participant claimed fatigue. Finally, these tests require minimal space and equipment and provide important information about everyday person's physical capacity.

The assessments applied in the present research showed adequate psychometric properties as confirmed by previous studies. The SRH demonstrated validity in a study with multiple ethnic groups (Chandola & Jenkinson, 2000). The Japanese version of the SF-8 meets the standard criteria for content and for construct and criterion validity, based on the national survey covering 1,000 Japanese general citizens in 2002 (Fukuhara & Suzukamo, 2004). The TUG showed a high inter-rater reliability among community-dwelling older adults (ICC = 0.98) and a high test-retest reliability; additionally TUG was able to correctly identify fallers and non-fallers (87%

sensitivity and specificity) (Shumway-Cook, Brauer, & Woollacott, 2000; Podsiadlo & Richardson, 1991; Steffen, Hacker, & Mollinger, 2002). The functional reach test also showed appropriate inter-rater reliability (ICC = 0.098) and a high test-retest reliability (ICC = 0.92) (Duncan, Weiner, Chandler, & Studenski, 1990). In Japan, OLS is widely used not only in clinical settings but also in community settings, and studies showed acceptable test-retest reproducibility and inter-rater reliability (Michikawa, Nishiwaki, Takebayashi & Toyama 2009; Franchignoni, Tesio, Martino, & Ricupero, 1998; Giorgetti, Harris, & Jette, 1998; Wolinsky, Miller, Andresen, Malmstrom, & Miller, 2005). The CS showed excellent reliability (0.89, 95% CI = 0.79, 0.95), sensitivity (95% CI) = 0.66 (0.55, 0.76), specificity (95% CI) = 0.55 (0.49, 0.61), relative risk (95% CI) = 2.0 (1.3, 3.0); and Likelihood ratio = 1.47 (Tiedemann, Shimada, Sherrington, Murray, & Lord, 2008). Finally, the HGS is also reliable as a study examined the reliability of HGS measured over a 12-week period and the test-retest measurements did not differ significantly over time on either side; additionally the intraclass correlation coefficients were 0.954 and 0.912 for the left and right hands, respectively (Bohannon, & Shaubert, 2005).

Statistical Analysis

The demographic information was described by the results of the descriptive analysis. We used One way ANOVA to verify the differences of the physical test results among the SRH groups. When a significant difference ($p < 0.05$) was found in the One way ANOVA analysis, we carried out the Tukey's Post Hoc to identify the SRH groups that differed according to the respective variable. Additionally, we used chi-square analysis to verify the difference of subjects divided by health sense groups (good, normal, and bad health conditions) who had score below and those who had score above the mean of each QOL assessment's domain.

RESULTS

The subjects were 51 community-dwelling Japanese women (mean age = 75.3 ± 6.0), 49% of them evaluated their health condition as good, 35.3% as normal, and 15.7% as bad health condition. They were then divided into three groups by their SRH, good health ($n = 25$), normal health ($n = 18$), and bad health ($n = 8$). There were statistical differences regarding the use of tobacco, frequency of medical consultation, and number of medications among these three groups. The group of subjects that evaluated their health as bad had more smokers and showed the highest frequency of medical consultation and highest number of medications (Table 1). No statistical differences were found regarding the other variables.

As shown in Table 2, body mass index was very similar among the groups. Considering waist circumference, a slight difference between those who evaluated their health as good and bad (78.3 ± 10.1 vs. 81.2 ± 17.8) was observed, but it was not statistically significant.

There were differences regarding physical performance in the FR and CS among the three groups. Additionally, there were some tendencies to show different performance in HGS and OLS. By the post hoc analysis, we verified the difference of FR, HGS, and CS between the normal and the bad health condition groups, and a

TABLE 1. Socio Demographic Characteristics of the Self-Rated Health Groups (n = 51)

		Good Valid% (n = 25)	Normal Valid% (n = 18)	Bad Valid% (n = 8)	p value
Age	(Mean ± SD)	76.4 ± 5.2	74.0 ± 7.2	74.8 ± 5.6	0.426
Education	Junior high school	21.7	25.0	14.3	0.850
	High school	30.4	12.5	28.6	
	Junior college	21.7	37.5	28.6	
	Technical course	17.4	6.3	14.3	
	University	8.7	18.8	14.3	
Live with	Alone	34.8	41.2	50.0	0.848
	Couple	34.8	29.4	12.5	
	3 or more	30.4	29.4	37.5	
Work	Do not work	75.1	66.7	100	0.683
	Volunteer	8.3	5.6	–	
	Agricultural work	8.3	11.1	–	
	Others	8.3	16.6	–	
Financial satisfaction	Satisfied	87.1	72.2	75	0.456
	Normal	4.3	27.8	25	
	Dissatisfied	8.6	–	–	
Go out home (per week)	Rarely	4.2	5.6	–	0.275
	1–2 times	16.7	5.6	–	
	3–4 times	20.8	22.2	62.5	
	Almost everyday	58.3	66.7	37.5	
Physical activity	Sedentary	13.0	27.8	12.5	0.401
	Almost everyday	26.1	16.7	37.5	
	2–3 times per week	56.5	44.4	25.0	
	1–2 times per month	4.3	11.1	25.0	
Tobacco	Yes	–	–	14.3	0.047
Alcohol	No consumption	70.8	50.0	42.9	0.375
	Rarely	8.3	5.6	28.6	
	Sometimes	12.5	33.3	14.3	
	Almost everyday	8.3	11.1	14.3	
Medical consultation	0 times	16.7	5.6	–	0.032
	1–2 times	37.5	22.2	–	
	3–4 times	8.3	27.8	14.3	
	5–6 times	12.5	33.3	14.3	
	7 times or more	25.0	11.1	71.4	
Hospitalization	Yes	12.5	–	–	0.189
Medication	Yes	80.0	88.9	100	0.332
Medications	(mean ± SD)	2.0 ± 1.5	2.9 ± 1.5	4.0 + 0	0.001

tendency was found for OLS. Moreover, CS was also different between the good and the bad groups. No difference was found for TUG (Table 2).

Considering general evaluation, without group distinction, the mean value of the SF1- General health was 49.3 ± 6.4, SF2- Physical functioning was 46.2 ± 6.3, SF3- Role physical was 46.9 ± 6.6, SF4- Bodily pain was 46.9 ± 8.0, SF5- Vitality was 51.4 ± 6.1, SF6- Social functioning was 48.3 ± 7.6, SF7- Role emotional was 51.1 ± 6.1, and SF8- Mental health was 50.1 ± 5.0.

We found a statistically significant difference regarding the general health, bodily pain, and vitality domains. In the general health and vitality domains, the majority

TABLE 2. Anthropometric Measures and Physical Performance in Each Level of Self-Rated Health ($n = 51$)

	Good ($n = 25$) Mean + SD	Normal ($n = 18$) Mean + SD	Bad ($n = 8$) Mean + SD	p value
Body mass index (kg/m^2)	22.3 ± 2.7	21.9 ± 2.6	22.4 ± 3.0	0.854
Waist circumference (cm)	78.3 ± 10.1	79.3 ± 9.8	81.2 ± 17.8	0.819
Timed up and go (sec)	7.1 ± 1.5	7.2 ± 1.5	7.9 ± 2.7	0.465
Functional reach (cm)	24.5 ± 5.7	28.0 ± 5.4^a	21.8 ± 5.7^a	0.025
One leg stand (sec)	19.8 ± 10.3	20.5 ± 9.6^c	10.1 ± 12.4^c	0.054
Five chair stands (sec)	7.8 ± 2.3^d	7.8 ± 2.1^e	10.7 ± $4.2^{d,e}$	0.022
Hand grip strength (kg)	20.9 ± 5.6	22 ± 3.6^b	17.1 ± 2.3^b	0.052

Notes: Post Hoc a: $p = 0.03$; b: $p = 0.04$; c: $p = 0.05$; d: $p = 0.02$; e: $p = 0.03$.

of the subjects who assessed their health as good and normal conditions had scores above the mean; while the majority of those who assessed their health as bad had scores below the mean. Concerning the bodily pain, the majority of the subjects who assessed their health as normal and bad conditions had scores below the mean, those in the good health condition had the same proportion of scores below and above the mean (Table 3).

DISCUSSION

Our findings showed that most of the subjects evaluated their health condition as good (49%) and that those who assessed their health condition as bad (15.7%) were a minority. According to the literature, SRH is strongly associated with mortality (Cesari et al., 2008; Ford et al., 2008; Okamoto et al., 2008). In accordance, a study

TABLE 3. Quality of Life in Each Level of Self-Rated Health

		Good Valid% (n)	Normal Valid% (n)	Bad Valid% (n)	p value
SF1 General health	High QOL	88 (22)	88.9 (16)	25 (2)	<0.01
	Low QOL	12 (2)	11.1 (2)	75 (6)	
SF2 Physical function	High QOL	54.2 (13)	61.1 (11)	25 (2)	0.23
	Low QOL	45.8 (11)	38.9 (7)	75 (6)	
SF3 Role physical	High QOL	64 (16)	66.7 (12)	25 (2)	0.11
	Low QOL	36 (9)	33.3 (6)	75 (6)	
SF4 Bodily pain	High QOL	50 (12)	23.5 (4)	—	0.02
	Low QOL	50 (12)	76.5 (13)	100 (8)	
SF5 Vitality	High QOL	76 (19)	70.6 (12)	25 (2)	0.03
	Low QOL	24 (6)	29.4 (5)	75 (6)	
SF6 Social function	High QOL	60.9 (14)	52.9 (9)	25 (2)	0.22
	Low QOL	39.1 (9)	47.1 (8)	75 (6)	
SF7 Role emotional	High QOL	44 (11)	41.2 (7)	25 (2)	0.63
	Low QOL	56 (14)	58.8 (10)	75 (6)	
SF8 Mental health	High QOL	45.8 (11)	47.1 (8)	25 (2)	0.54
	Low QOL	54.2 (13)	52.9 (9)	75 (6)	

Notes: High QOL represents the values above the mean and low QOL represents those values below the mean.

showed that the strongest predictor of death was "poor" or "fair" self-rated health (with 52.3% and 28%, respectively, of women in these categories dying) (Okamoto et al., 2008), we then assume that the minority needs special attention.

Additionally, poorer SRH and lifestyle habits, such as being a current or ex-smoker, physical inactivity, being a non-drinker of alcohol, being underweight, older age, lower educational level, and being single or widowed; are other examples of significant factors associated with increased mortality (Ford et al., 2008). In our study, the group of subjects who evaluated their health as bad had more smokers and showed a higher frequency of medical consultation and more medications than the others.

Regarding physical performance, our findings showed that those who evaluated their health as bad had poorer physical performance in FR comparing with those who evaluated it as normal, and in CS comparing with those who evaluated as good and normal conditions. Cesari et al. (2008) found an independent prediction of CS and SRH to mortality in older adults; however, authors softened the SRH results stating that participants with a good physical performance had a lower risk of dying compared to those with poor performance, independently of their self-perceived health status.

Our data also indicate that those who evaluated their health as bad presented lower performance on HGS and OLS than the other groups. However, the difference was statistically significant only in HGS between normal and bad groups; additionally, no difference was found for TUG. Different from our findings, Jylha et al. (2001) found a strong graded association of fair or poor SRH with increasing severity of walking difficulty in an age adjusted model. They also found that mobility was a central constituent of SRH for older women. Moreover, they did not find a significant independent effect of SRH on the other performance measures (chair stands, balance and grip strength) once mobility was accounted for. The reference values for TUG in healthy Japanese elderly are 6.60 s with maximum effort and 8.86 s at the usual pace (Kamide, Takahashi, & Shiba, 2011). In our study, we requested them to do with their maximum effort during test, and we found a mean of 7.1 ± 1.5, 7.2 ± 1.5, and 7.9 ± 2.7 for good, normal, and bad groups, respectively. In our understanding, mobility was not a problem in the studied participants, and then the other physical measures were different among SRH groups, but not TUG. Possible reasons are hypothesized ahead.

Self-rated health (SRH) is a subjective assessment based on the personal beliefs and also on the living context, and it is possible to credit some different results among the SRH studies to the cultural aspects that require different physical patterns. For example, Japanese people, particularly older adults, keep the tradition such as sleeping in *tatami*, sitting on the floor, using the Japanese bathroom (squatting position), and bathing in the *ofuro*; thus, all these differences in their daily routine intensely require certain physical abilities such as stretching (here evaluated by FR), muscle power (CS), strength (HGS), and balance (OLS) that seem to be relevant based on the present findings. However, we did not investigate their lifestyle in detail, so we cannot extend our results until this point. Certainly, further researches towards the SRH with a cross-cultural view are needed to clarify this inference.

Concerning QOL, those reporting a bad health condition in our study showed poorer results in general health and vitality domains comparing with the other SRH groups; and in bodily pain, comparing solely with the good condition group. Our study provides evidence of the cycle involving SRH, physical performance and QOL. These data can be supported by another study indicating that limitations in subjective health are particularly experienced by older people with impaired physical ability that lead to limitations in everyday management associated with the risk of losing independence, which is highly significant for QOL (Gunzelmann, Hinz, & Brähler, 2006).

Another study with Japanese older adults suggested the importance of maintaining the physical health to assure mental and social health of older adults. Their findings indicated that people who can keep an overall healthy state were those with a good physical condition that may deal with the daily life demands independently with a paucity of disease, or those who maintain a heightened psychological well-being and active connections with society on the basis of being in satisfactory physical condition (Yuasa et al., 2012). Furthermore, considering a 10-year follow up, the researchers found that a good QOL was a strong positive correlate of both mobility and SRH in older women (Sirola et al., 2010).

Self-rated health (SRH) appears to be a multidimensional phenomenon and the concept of health of older adults is not an isolated event, but rather it involves all the aspects of their lives and the living context. And we, as health providers, must develop skills in understanding the health aspects and the demands of the older adults to attend them adequately. We should attempt to give special attention to their physical condition/performance; however, we should not fragment the health just on this basis, extending our care to the other relevant aspects such as QOL including the mental and the social conditions. In a community setting, SRH could be used to save time when screening older adults due to its association with QOL and physical performance. Then, for those representing the self-reported bad health condition, one should attempt further assessments.

Our study has several limitations. First, it has a cross-sectional design and we cannot extend the results to affirm that the physical performance and QOL are predictors for SRH. Another limitation is that the sample size was small and we recruited only the participants from an urban city in Japan. Therefore, further studies should be conducted with a larger sample size and participants of different areas, if possible, of different countries; and to apply different measurements to continue the investigation among the dimensions of health that SRH captures.

CONCLUSIONS

Our present study contributes to understand that the self-ratings of health may be modified by physical performance and QOL among older women in Japan. Those who assessed their health as bad had worst physical performance in FR, HGS, and CS, and also presented lower QOL scores in general health, bodily pain, vitality than other SRH groups. We encouraged the use of the SRH assessment and the interpretation of its results based on the present findings such as associating the SRH of older women with their physical performance and QOL.

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