The effectiveness and safety of modest exercise in Japanese patients with chronic kidney disease: a single-armed interventional study

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Abstract

Background: Poor physical ability and skeletal muscle wasting are common in chronic kidney disease (CKD) patients, who may experience a decline in daily activity and, in turn, increased mortality. The purpose of this study was to evaluate the effectiveness and safety of modest exercise in patients with stable CKD.

Methods: Forty-seven CKD patients were enrolled in a six-month group program for aerobic and resistance exercise by self-training. Parameters of physical function and clinical laboratory markers, including renal function, were measured.

Results: The International Physical Activity Questionnaire score improved from a baseline of 36.6 ± 13.8 to 40.1 ± 14.8 after the exercise program ($P < 0.001$). The number of daily steps increased from 6141 ± 2620 to 7679 ± 3026 ($P < 0.001$). We detected significant changes in the 30-second chair stand test (from 20.7 ± 5.3 to 26.0 ± 5.9 repetitions; $P < 0.001$), single-foot standing test (from 53.0 ± 44.3 to 68.4 ± 43.0 seconds; $P = 0.001$) and 6-minute walk (from 501.6 ± 63.8 to 528.7 ± 71.8 m; $P = 0.02$). Moreover, body weight, waist circumference, and blood pressure were significantly reduced. No significant deterioration was observed in the estimated glomerular filtration rate. Proteinuria significantly decreased in 21 patients.

Conclusion: Our modest exercise program improved the physical performance of CKD patients without deterioration of renal function. These results suggest that exercise rather than excess rest should be recommended for CKD patients to avoid muscle wasting.

Subheading: Exercise in Japanese patients with chronic kidney disease

Keywords: Chronic kidney disease, physical performance, exercise

Introduction

Patients with chronic kidney disease (CKD) are prone to impaired physical activity and reduced physical function because of protein-energy wasting, persistent inflammation, metabolic acidosis and others symptoms, leading to a vicious cycle of kidney dysfunction and mortality [1, 2]. Indeed, exercise capacity is significantly reduced in both pre-dialysis [3, 4] and dialysis CKD patients [5, 6]. Moreover, sedentary dialysis patients showed a 62% higher risk of death compared to non-sedentary patients [7]. Trivial kidney dysfunction is associated with poor physical function in geriatric patients [8].

Exercise rehabilitation has been generally utilized for patients with diabetes, peripheral vascular disease, cardiovascular disease and others [9, 10]. The health benefits of mild walking in pre-dialysis CKD patients have recently been reported [11]. Muscular endurance exercise training was also shown to increase muscle function and walking capacity in moderate CKD patients to an extent comparable to healthy control subjects [12].

The purpose of the present study was to evaluate whether modest exercise may improve physical activity and function without deterioration of renal function and proteinuria in Japanese patients with stable CKD.

Materials and Methods

Ethical statement

The protocol of the study was approved by the ethical committee of the Nagoya University Hospital (2012-00083057). The study was conducted in accordance to hospital guidelines. All patients provided written informed consent prior to participation in this study.

Design, setting and participants

We conducted a single-armed interventional study. Pre-dialysis CKD patients were recruited from the outpatient clinic of the Department of Nephrology at Nagoya University Hospital during January 2012 to June 2013 for a six-month modest group exercise class. Exclusion criteria were cardiovascular disease within six months, active diabetic retinopathy, diagnosis of peripheral arterial disease, uncontrolled hypertension, progressing renal disease and nephrotic syndrome treated with immunosuppressive therapy. Sixty-one CKD patients (stages 1 to 5) volunteered for the program. Of these volunteers, 14 patients withdrew due to reconsideration, change of hospital and depression and 47 participated in the study and completed the six-month program. The primary causes of renal disease were glomerulonephritis (n = 8), nephrosclerosis (n = 24), diabetic nephropathy due to diabetes mellitus type 2 (n = 3), nephropathy due to obesity (n = 9) and unilateral kidney (n = 3).

Exercise program

The exercise class consisted of six sessions per month at 1.5-2 h per session. Resistance training using 3-4 metabolic equivalents (METs) and effective walking to burn fat and increase muscle were demonstrated to the participants. This exercise program was designed so that the participants could repeat it at home. We used a rating of perceived exertion (RPE) to determine the appropriate exercise intensity for each participant. RPE is quantified by the Borg RPE scale, with an RPE of 6 representing "no feeling of exertion," and 20 corresponding to "very, very hard". Moderate activities register from 11 to 14 on the Borg scale ("fairly light" to "somewhat hard"), while vigorous activities usually rate 15 or higher ("hard" to "very, very hard") [13]. We aimed to achieve an exercise intensity of 12-14 on the RPE scale. Participants also received standard care including diet therapy, mental support and counseling for CKD.

The assessment of physical activity and function

Physical activity was assessed by the International Physical Activity Questionnaire (IPAQ) [14]. In brief, the IPAQ is used to a self-recording report of the number of days a week and time that a patient performs high-intensity or moderate physical activity. This study used the short version of the IPAQ, which contains seven questions about activity intensity, including vigorous and moderate intensity exercises, walking and sedentary activities over the last seven days. IPAQ defines moderate activity as increase in respiration rate, heart rate and sweating sustained for at least 10 min. This is equivalent to 3-6 METs based on daily physical activity. Vigorous physical activities are defined as those producing vigorous increases in respiration rate, heart rate and sweating sustained for at least 10 min. The metabolic equivalent value is above 6 MET. In addition, the MET-hours per week for walking, moderate intensity activity, and vigorous intensity activity were calculated as follows: walking = 3.3 METs × hours × days; moderate activity = 4.0 METs × hours × days; and vigorous activity = 8.0 METs ×

hours × days. The participants completed the self-training records by recording resistance training and the number of steps, as measured by a pedometer. Physical strength metrics were assessed by handgrip strength, 30-second chair stand test, sit and reach test, single-foot standing test with eyes open and a 6-minute walk.

Laboratory biomarkers

We measured height and body weight (BW), waist circumference and calculated body mass index (BMI). Blood pressure (BP) was measured twice after a rest period of 5 min with a digital automatic blood pressure monitor (HEM-9000AI, Instrument Ltd, OMRON, Japan) and averaged for analysis. Serum creatinine (Cre), hemoglobin A1c National Glycohemoglobin Standardization Program (HbA1c: NGSP), high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), aspartate aminotransferase (AST), alanine aminotransferase (ALT) and γ-glutamyl transpeptidase (ɤ-GTP) were measured at the clinical laboratory at the Nagoya University Hospital using an automatic analyzer. Proteinuria was measured in spot urine at an outpatient clinic and we used the direct value of spot urine measured on one occasion to analyze. Estimated glomerular filtration rate (eGFR) was calculated by the equation using single measured serum Cre level, age and sex [15].

Statistical analysis

Changes in measurements before and after intervention were determined using a *t*-test for paired samples, Wilcoxon's signed-rank test or Spearman's rank correlation coefficient by using a statistical software package (SPSS for Windows v20). Statistical significance was defined as 5% in a two-tailed test.

Results

Clinical characteristics and laboratory biomarkers

The characteristics of the enrolled patients are shown in Table 1. The subjects included 24 men (51%) and had a mean age of 68.8 ± 11.1 years. The mean BMI was 25.3 ± 3.8 kg/m^2 and 21 of 47 participants (45%) were obese and had a BMI over 25 kg/m^2. The patients received oral medications for hypertension (89%) and dyslipidemia (72%). Renin-angiotensin system inhibitors (ARB) and calcium channel blockers were used in 33 patients (70%). Statins were used in 15 patients (32%).

Changes of physical activity and clinical biomarkers

Effects of exercise intervention on physical activity and clinical indicators are shown in Table 2. The amount of physical activity at home as assessed by the IPAQ score increased significantly from 36.6 ± 13.8 to 40.1 ± 14.8 METs × hours/week ($P < 0.001$). Although only 41 participants completed the self-monitoring sheet with the number of daily steps, this parameter increased from 6141 ± 2620 to 7679 ± 3026 ($P < 0.001$). Body weight, waist circumference, systolic blood pressure and diastolic blood pressure significant decreased from 66.1 ± 12.1 to 65.7 ± 12.2 kg (P = 0.04), from 90.6 ± 9.5 to 88.5 ± 9.2 cm (P = 0.001), from 134.5 ± 19.3 to 127.7 ± 17.0 mmHg (P = 0.01), from 78.4 ± 13.9 to 70.7 ± 21.1 mmHg (P < 0.001), respectively. No significant difference between the pre- and post-exercise classes was observed in the eGFR. Although proteinuria did not increase after exercise for the total patient population, a significant decrease in proteinuria, from 0.39 (0.15 - 2.68) g/gCre to 0.27 (0.00 - 1.65) g/gCre, was observed in 21 patients with a baseline measurement of 0.15 g/gCre. Furthermore, we investigated whether proteinuria decreased substantially in patients with urinary protein creatinine ratio (UPCR) ≧ 0.5 g/gCre. In this study, the only 8 subjects showed UPCR ≧ 0.5 g/gCre and their proteinuria tended to decrease after excise program from 0.96 (0.50-2.68) to 0.77 (0-1.65) g/gCre (P = 0.07).

Changes of anti-hypertensive drugs were not restricted during the study periods. To determine whether excise contributed lowering blood pressure and anti-proteinuria, but not anti-hypertensive drugs, we checked the actual applied dosage and kind of anti-hypertensive drugs. There were six patients who were subject to change prescription of anti-hypertension drugs during the exercise classes, increment dosage of

ARB in two, decrement dosage of ARB in two and start of additional diuretics in two. To confirm exercise to lower blood pressure, we recalculated the changes of blood pressure in the subgroup who received the refilled prescriptions. They still showed significant improving systolic blood pressure and diastolic blood pressure from 133.0 ± 19.4 to 127.2 ± 17.4 mmHg ($P = 0.03$) and from 76.8 ± 14.3 to 71.2 ± 13.7 mmHg ($P < 0.01$), respectively. Moreover, as for the effect of anti-proteinuria, 18 patients who met both criteria of no-changing anti-hypertension drugs and over UPCR ≧ 0.15 g/gCre also showed significant decreased from 0.32 (0.15 - 1.76) to 0.20 (0.00 - 1.65) g/gCre ($P = 0.049$) after exercise program.

Reduction in body weight contributed to proteinuria reduction

Significant reduction of body indicators and the amount of protein in spot urine through the exercise program was detected in 21 patients positive for proteinuria prior to the start of the program. To elucidate the factors involved in proteinuria reduction, we analyzed the correlations between changes in proteinuria (Δ proteinuria in spot urine), BW (Δ BW) and blood pressure (Δ systolic blood pressure and Δ diastolic blood pressure), physical activity in daily life (Δ physical activity), and the number of steps (Δ steps). In Spearman's rank test, Δ proteinuria in spot urine correlated with Δ BW ($r = 0.29$, $P = 0.04$), whereas it was not correlated with Δ systolic blood pressure, Δ diastolic blood pressure, Δ physical activity or Δ steps (Table 3a). Moreover, when checked these correlations in patients with UPCR ≧ 0.15g/gCre, Δ proteinuria in spot urine correlated with Δ diastolic blood pressure ($r = 0.518$, $P = 0.016$), Δ systolic blood pressure ($r = 0.415$, $P = 0.06$) and Δ weight ($r = 0.456$, $P = 0.038$) (Table 3b).

Effect on physical performance

Next, we evaluated physical strength metrics, including handgrip strength, 30-second chair stand test, sit and reach test, single-foot standing test with eyes open and a 6-minute walk (Table 4). We detected significant changes in the 30-second chair stand test (from 20.7 ± 5.3 to 26.0 ± 5.9 repetitions; $P < 0.001$), sit and reach test (from 33.5 ± 11.0 to 36.3 ± 11.2 cm; $P = 0.005$), single-foot standing test with eyes open (from 53.0 ± 44.3 to 68.4 ± 43.0 seconds; $P = 0.001$) and 6-minute walk (from 501.6 ± 63.8 to 528.7 ± 71.8 m; $P = 0.02$). No significant difference was observed in handgrip strength.

The patients were divided into three groups based on eGFR. Group 1 patients had an eGFR ≧ 60 ml/min/1.73 m^2; Group 2, 59-30 ml/min/1.73 m^2; and Group 3, < 30 ml/min/1.73 m^2. Significant improvements were observed in Groups 1 and 2, similar to the total patient population. For Group 3 patients, no significant improvements in the sit and reach test and 6-minute walk were observed.

Safety evaluation of exercise in CKD patients

The mean eGFR six months before the baseline, at the baseline, and six months after the baseline was 48.9 ± 22, 47.7 ± 22.1, and 47.3 ± 21.0 ml/min/1.73m^2, respectively (Figure 1). There was no significant difference between the changes in eGFR in the six months before intervention (-1.1 ± 5.9 ml/min/1.73m^2) and during the six months of exercise training (-0.5 ± 5.4 ml/min/1.73m^2) (P = 0.62). Furthermore, to confirm the safety in severer patients with moderate renal dysfunction as Group3 and over, or with macroproteinuria (UPCR ≧ 0.5g/gCre), the subgroup analysis was performed. While there were 34 patients in Group 3 and over, we didn't find to deteriorate their eGFR (the six months before intervention; -1.33 ± 5.50 ml/min/1.73m^2, during the six months of exercise training; 0.32 ± 3.64 ml/min/1.73m^2, P = 0.22). However, when checked the change of eGFR in 8 patients with macroproteinuria, renal function was subtle prone to aggravate even there could not reach a significant difference (the six months before intervention; -0.16 ± 2.08 ml/min/1.73m^2, during the six months of exercise training; -1.80 ± 4.02 ml/min/1.73m^2, P = 0.31).

Discussion

This study demonstrates that modest exercise could improve physical function and strength metrics in Japanese patients with stable CKD. In particular, these improvements were even evident in patients with stage 4 or 5 CKD, who experience relatively severe renal dysfunction. Though many physicians still question whether exercise might impair renal function and/or increase proteinuria in CKD patients, we demonstrate that the moderate exercise intensity applied in this study could circumvent these problems. Moreover, there was a notable reduction in proteinuria in patients with positive proteinuria defined as over 0.15 g/gCre relative to the reduction in body weight.

In this study, we found a slight but significant improvement in physical strength. Heiwe et al. [12] determined that elderly pre-dialysis patients could improve muscle strength through muscle endurance exercises using a leg machine three times per week for 3 months at a training center. Moreover, Castaneda et al. [16] reported that supervised resistance training three times per week for 3 months lead to increased muscle strength in patients with stage 4 and 5 CKD. Rossi et al. [17] reported that supervised resistance training with aerobic exercises three times per week for 3 months restored physical functions in moderate to severe CKD patients, as assessed by methods similar to those used in our study. Though we cannot compare the efficacy of these studies to our study, we believe that broad use of easy home exercises without any special equipment contributes to physical strength and better fitness. Moreover, lower physical activity is getting recognized as a risk factor for mortality in these patients, and deeply associated with poor outcomes [18]. Although there have been reported a limited number of study to access the direct association, some studies showed exercise training contribute shortening hospitalization [19, 20] and longer survival [21] with better physical functions. We believe that exercises should be an effective treatment to improve survival in CKD patients.

Exercise also improves body indicators. In this study, we found the correlation between ΔBW and Δ proteinuria. It was reported that incident macroalbminuria was associated with obesity as well as unhealthy diet in the US community-based prospective cohort study [22]. In Japanese community-based annual examinations, obese subjects showed an increased risk of developing proteinuria [23]. Although its mechanism is not yet explored, lipotoxicity [24, 25], inflammation and oxidative stress

[26] related to the proliferated adipose tissues may play a role in addition to increased renal plasma flow and up-regulated intra-glomerular pressure in proportion to body weight gain. Indeed, it was summarized in recent systematic review of clinical trials that weight loss is associated with decreased proteinuria and micro albuminuria [27]. Although we failed to demonstrate the direct mechanism to explain a decrease in proteinuria via body weight loss, we speculate that because the patients who lost their body weight accompanied reduction in their waist circumferences, suppress of adipose tissues might contribute to decrease intra-glomerular load and damage as we stated above.

Boyce et al. [28] found that aerobic exercise may play a role in decreasing blood pressure by increasing physical performance in pre-dialysis CKD patients with hypertension. Recently, it was reported that patients with CKD stage 4–5 who performed intensive aerobic exercise and resistance training with speed walking for six months required lower amounts of anti-hypertensive drugs and had finer blood pressure control [11]. We also found the significant decrease in blood pressure, suggesting that exercise might play a role in preventing hypertension, though there was no direct correlation between blood pressure and other clinical indicators. In this study, there was correlation between ΔBW and Δ proteinuria but no correlation between ΔBP and Δ proteinuria. It was difficulty to confirm decrement of proteinuria in the patients without proteinuria. Thus, as we showed in Table 3b, in UPCR ≧ 0.15g/gCr groups, Δ proteinuria in spot urine correlated with Δ diastolic blood pressure .

Exercise has not been recommended for kidney disease patients in the past, since exercise could cause renal injury, such as a reduction in renal blood flow [29] and increase in proteinuria [30]. Based on these historical observations, guidelines issued by the Japanese Society of Nephrology still recommend restricting sports for pediatric kidney disease patients [31]. However, it was recently reported in a systematic review that weight loss intervention attained to decrease proteinuria and BP in obese CKD patients [32]. Lifestyle modification including an exercise program should be encouraged in the guideline released by Kidney disease improving global outcomes (KDIGO) [33] although this guideline also mentioned that an exercise program for lower-weight CKD patients with suspected malnutrition or inflammation still might be controversial. We supposed that our study proceeded in safety because our study subjects were accounted for mainly CKD with larger BMI but not with PEW or frail whom exercise has not been recommended. Baria et al. [34] showed that initial renal dysfunction caused by aerobic training resolved within 12 weeks in moderate CKD patients with obesity. Fuiano et al. [35] demonstrated that the increase in post-exercise proteinuria was only temporary, lasting only two hours. In our study, the participants maintained their initial eGFR levels and proteinuria improved rather than worsened. Moreover, because higher physical activity levels are reported to be associated with a slowing of eGFR loss in CKD patients [36], we speculate that exercise may have a potential for renal protection via support of physical activity.

Limitations of our study should be noted. First, the sample size is small, particularly subgroup analysis divided by GFR stage. And since we provided only 6 months' observation, it might be not enough to evaluation renal function. Second, the study design was single-armed and lacked a control group. Because the participants in this study were simultaneously educated on diet and information on kidney disease through the exercise program, we could not evaluate the direct effect of exercise alone. Moreover, changes to medication, including anti-hypertensive drugs, were not restricted.

Finally, exercise at home was assessed by self-reporting and objective measurement tools to quantify physical activity should be used for more accurate evaluation.

In conclusion, our modest exercise program enabled stable CKD patients to improve physical strength and function without deterioration of renal functions. These results suggest that exercise rather than excess rest should be recommended for CKD patients to avoid muscle wasting.

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Legend to Figure

Figure 1. Change of estimated glomerular filtration rate between the six months before intervention and during the six months of exercise training.

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Table1. Characteristics and psychological data of the subjects.

	n=47, mean±SD, n (%)
Men	24 (51)
Age	68.8 ± 11.8
Hight (cm)	161.4 ± 9.4
Body Weight (kg)	66.1 ± 12.1
BMI (kg/m^2)	25.3 ± 3.8
Grouping CKD stage	
Group1【eGFR≧60 】	11 (23)
Group2【60>eGFR≧30】	24 (51)
Group3【eGFR＜30】	12 (26)
Medication	
High blood pressure	42 (89)
ARB / ACE inhibitor	33 (70)
CCB	15 (32)
Hyperlipidemia	34 (72)
Statin	24 (39)
Hyperuricemia	20 (43)
Clinical history	
Diabetes	19 (40)
Past CVD	11 (23)
History of smoking	
Current	0
Past	27 (57)
Never	20 (43)

eGFR: estimated glomerular filtration rate, ARB: Angiotensin II Receptor Blocker, ACE inhibitor: angiotensin-converting enzyme inhibitor, CCB: calcium channel blocker

Table 2. Effects of exercise intervention on physical activity on daily life, renal function, clinical indices, and body indicators

	baseline	after 6 month's exercise training	P-value
Physical activity in daily life (Mets*Hour/Week)：IPAQ	36.6 ± 13.8	40.1 ± 14.8	<0.001***
Daily average number of steps (Steps / Day)	6141 ± 2620	7679 ± 3026	<0.001***
Clinical examination			
HDL-C (mg/dl)	48.9 ± 12.4	49.6 ± 12.8	0.59
LDL-C (mg/dl)	100.7 ± 25.1	105.1 ± 28.1	0.22
AST (mg/dl)	24.0 ± 8.7	23.2 ± 7.1	0.44
ALP (mg/dl)	22.6 ± 13.8	20.5 ± 11.3	0.1
γGTP (mg/dl)	32.4 ± 28	30.7 ± 30	0.44
HbA1c (NGSP)(%)	6.05 ± 0.43	6.04 ± 0.49	0.07
Body index			
Body weight (kg)	66.1 ± 12.1	65.7 ± 12.2	0.04*
BMI (kg/m^2)	25.3 ± 3.8	25.1 ± 3.9	0.06
Waist (cm)	90.6 ± 9.5	88.5 ± 9.2	<0.001***
Systolic blood pressure (mmHg)	134.5 ± 19.3	127.7 ± 17.0	0.01*
Diastolic blood pressure (mmHg)	78.4 ± 13.9	70.7 ± 21.1	<0.001***
Renal function			
eGFR (ml/min/1.73 m^2)	47.7 ± 22.1	47.3 ± 21.0	0.59
Point of proteinuria (g/gCre)			
ALL (n = 47)	0.10 (0-2.68)	0.11 (0-1.65)	0.7
UPCR≧0.15g/gCr (n = 21)	0.39 (0.15-2.68)	0.27 (0-1.65)	0.04*
UPCR＜0.15g/gCr (n = 26)	0.05 (0-0.12)	0.08 (0-0.25)	0.09

Parametric data are presented as mean ± standard deviation (SD). Nonparametric data are presented as median (range) score in the IPAQ International Physical Activity Questionnaire. It used as a standard measure to estimate habitual practice of physical activities of populations. BMI, body mass index; AST, aspartate aminotransferase; ALP, alanine aminotransferase; γGTP, γ-glutamyl transpeptidase; HDL, high-density lipoprotein; LDL, low-density lipoprotein; NGSP, National Glycohemoglobin Standardization Program. We excluded LDL data of one patient who changed oral medication during the investigation period. eGFR, estimated glomerular filtration rate. * represents $P < 0.05$; **, $P < 0.01$; ***, $P < 0.001$.

Table 3

a. Correlation of proteinuria decrease (Δ Proteinuria in spot urine) and weight loss at all participants.

	ρ	P-value
Δ BW (kg)	0.29	0.04*
Δ WC (cm)	0.23	0.17
Δ Physical activity (Mets*Hour/Week) ¶	0.13	0.94
Δ Daily steps (Steps/Day) ¶	0.22	0.24
Δ Systolic blood pressure (mmHg)	0.05	0.71
Δ Diastolic blood pressure (mmHg)	0.2	0.17
b. Correlation of proteinuria decrease (Δ Proteinuria in spot urine) and weight loss at UPCR≧0.15g/gCr groups.		
Δ BW (kg)	0.46	0.04*
Δ WC (cm)	-0.11	0.64
Δ Physical activity (Mets*Hour/Week) †	0.15	0.54
Δ Daily steps (Steps/Day) †	0.11	0.18
Δ Systolic blood pressure (mmHg)	0.41	0.06
Δ Diastolic blood pressure (mmHg)	0.52	0.02*

Δ Proteinuria in spot urine = (initial proteinuria in spot urine) – (final proteinuria in spot urine). Δ BW (body weight) = (initial BW) – (final BW). ΔWC (waist circumference) = (initial WC) – (final WC). Δ Physical activity = (initial physical activity) – (final physical activity). Δ number of steps = (initial number of steps) – (final number of steps). Δ Systolic blood pressure = (initial systolic blood pressure) – (final systolic blood pressure, Δ Diastolic blood pressure = (initial diastolic blood pressure) – (final diastolic blood pressure).

* represents $p < 0.05$.

Table 3 **a**; N = 47, ¶N = 41, **b**; N = 21, †N = 18

Table 4. Effects of exercise intervention on physical performance in patients grouped by CKD stage.

	n	Baseline	After 6 months of exercise training	P-value
Physical strength metrics				
Grip strength measurement (kg)				
ALL	47	30.1 ± 9.7	30.3 ± 9.5	0.49
Group1【eGFR≧60 】	12	27.6 ± 14.0	28.5 ± 13.3	0.35
Group2【60>eGFR≧30】	24	31.5 ± 7.7	31.2 ± 7.9	0.46
Group3【eGFR＜30】	11	29.8 ± 8.8	30.7 ± 8.5	0.22
30-second chair stand test (repetitions)				
ALL	47	20.7 ± 5.3	26.0 ± 5.9	＜0.001***
Group1【eGFR≧60 】	12	22.5 ± 5.9	26.9 ± 6.4	0.006**
Group2【60>eGFR≧30】	24	20.2 ± 5.5	26.3 ± 6.3	＜0.001***
Group3【eGFR＜30】	11	19.9 ± 4.1	24.5 ± 4.8	0.001**
Physical function metrics				
Sit and reach test (cm)				
ALL	47	33.5 ± 11	36.6 ± 11.2	0.005**
Group1【eGFR≧60 】	12	33.8 ± 13.1	36.8 ± 13.6	0.009**
Group2【60>eGFR≧30】	24	34.9 ± 10.5	38.8 ± 9.8	0.049*
Group3【eGFR＜30】	11	30.8 ± 10.3	31.6 ± 12.1	0.32
Single-foot standing test with eyes open (s)				
ALL	47	53.0 ± 44.3	68.4 ± 43.0	0.001**
Group1【eGFR≧60 】	12	59.8 ± 47.2	72.9 ± 43.8	0.089
Group2【60>eGFR≧30】	24	64.4 ± 45.9	79.4 ± 40.8	0.004**

Group3【eGFR＜30】	11	20.6 ± 13.3	39.5 ± 36.2	0.049*
6-minute walk (m)				
ALL	47	501.6 ± 63.8	528.7 ± 71.8	0.02*
Group1【eGFR≧60 】	12	504.6 ± 80.6	527.1 ± 94.1	0.04*
Group2【60>eGFR≧30】	24	511.9 ± 63.3	544.3 ± 67.9	＜0.001***
Group3【eGFR＜30】	11	475.9 ± 38.5	496.4 ± 40.1	0.26

Parametric data are presented as mean ±standard deviation (SD). Nonparametric data are presented as median (range). * represents $p < 0.05$; **, $p < 0.01$; ***, $p < 0.001$.