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Original Article

ORIGINAL ARTICLE

The impact of quality of life on the survival of elderly patients with end-stage renal disease: a prospective multicenter cohort study in Korea

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ABSTRACT

Background. Quality of life (QOL) is associated with mortality in dialysis patients. However, the impact of QOL index or score on elderly patients undergoing maintenance dialysis is unclear. We analyzed the relationship between QOL domains and survival in elderly end-stage renal disease (ESRD) patients on dialysis.

Methods. We included 492 incident ESRD patients aged ≥65 years from a Korean nationwide prospective cohort study who were assessed for QOL with a follow-up duration of 67.3 ± 34.6 months after dialysis initiation. Their QOL was evaluated using the Kidney Disease Quality of Life (KDQOL) instrument, and the effect of each QOL domain on mortality was analyzed. Multivariable Cox regression analysis was performed to identify independent risk factors for death after adjusting for confounding factors.

Results. Low physical component summary (PCS) and Short Form-36 score were significantly associated with low survival rate ($P < .001$ and $P = .017$, respectively), whereas the mental component summary and ESRD-targeted item scores were not correlated with survival rate. Multivariable Cox regression analysis confirmed that only a high PCS score was associated with better survival (hazard ratio 0.71; 95% confidence interval 0.52–0.97; $P = .031$). Linear regression analysis revealed that age, sex, modified Charlson comorbidity index, albumin and intact parathyroid hormone were associated with PCS. Among the PCS items, only the physical functioning score was significantly associated with mortality ($P = .017$).

Conclusion. PCS was an independent risk factor for death in elderly ESRD patients. A higher physical functioning score was associated with a better outcome, suggesting the importance of physical condition in elderly dialysis patients.

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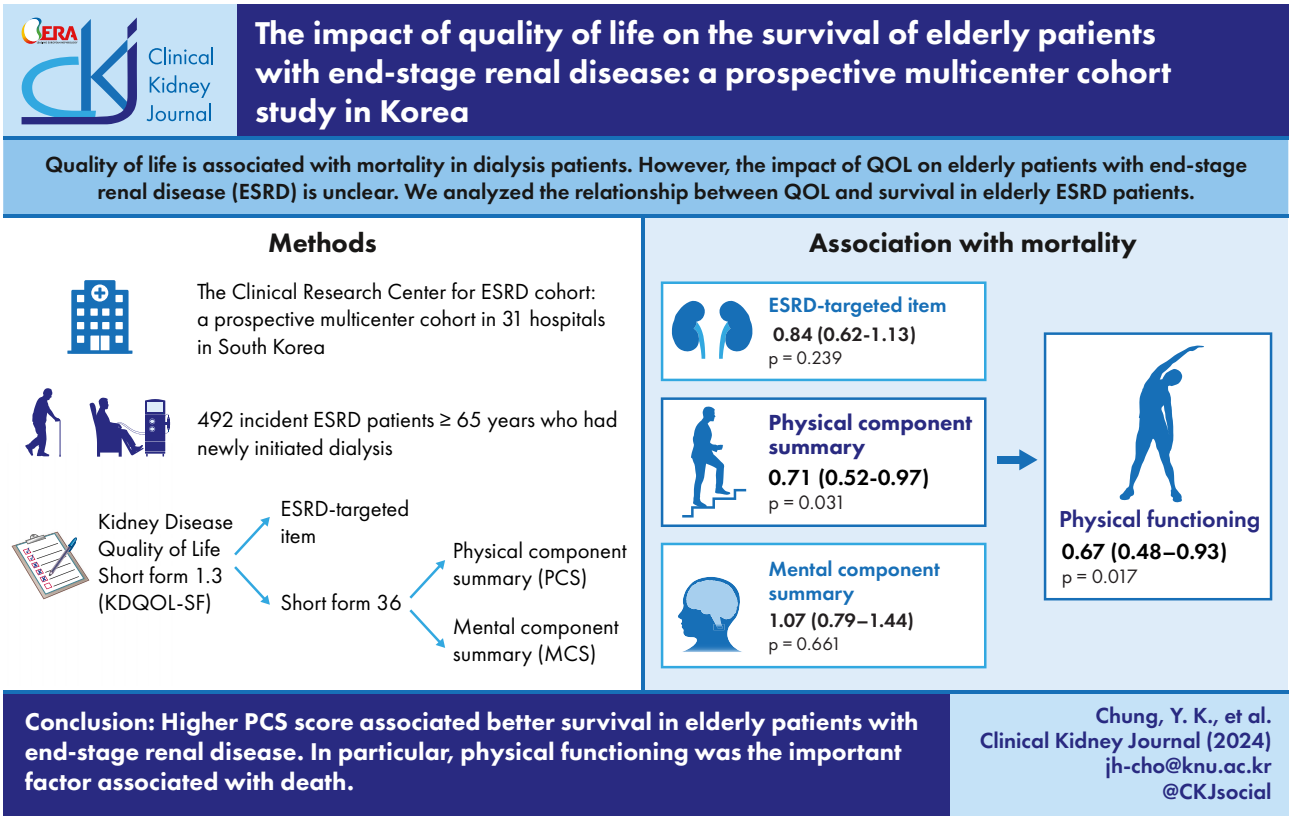
GRAPHICAL ABSTRACT



Keywords: dialysis, elderly patient, end-stage renal disease, quality of life, survival

KEY LEARNING POINTS

What was known:

- Quality of life (QOL) is associated with mortality in dialysis patients; however, the relationship between QOL and long-term prognosis has been studied with limited data specifically in elderly end-stage renal disease (ESRD) patients.
- We aimed to analyze the association between QOL and mortality in Korean elderly ESRD patients.

This study adds:

- We confirmed the independent impact of QOL that predicts long-term prognosis in elderly ESRD patients.
- Low physical health status was associated with high mortality in elderly ESRD patients and especially physical functioning was the important factor associated with death.

Potential impact:

- Because the physical performance of elderly ESRD patients could be an important prognostic predictor related to survival, attention to QOL and monitoring of physical functioning are essential for elderly ESRD patients.

INTRODUCTION

Survival of end-stage renal disease (ESRD) patients has improved due to recent advances in dialysis. However, most ESRD patients still have an impaired quality of life (QOL) compared with the general population [1]. QOL is associated with mortality in ESRD patients [1, 2]. Therefore, QOL assessment is important for predicting mortality and hospitalization of patients with ESRD [3, 4].

QOL is defined as an individual's perceived physical and mental health status. In general, ESRD patients have low physical performance and activity, and experience more anxiety and depression than the general population [5–7]. Studies have shown that dialysis patients with poor physical function have a lower survival rate than those with good physical activity [5, 8]. Poor mental health status has also been reported as a risk factor for hospitalization and death in ESRD patients [9, 10]. Several studies have investigated racial differences in QOL among dialysis patients [11–13]. Lopes *et al.* [14] reported that African Americans showed higher QOL scores for all three components [mental component summary (MCS), physical component summary (PCS) and kidney disease component summary (KDCS)]

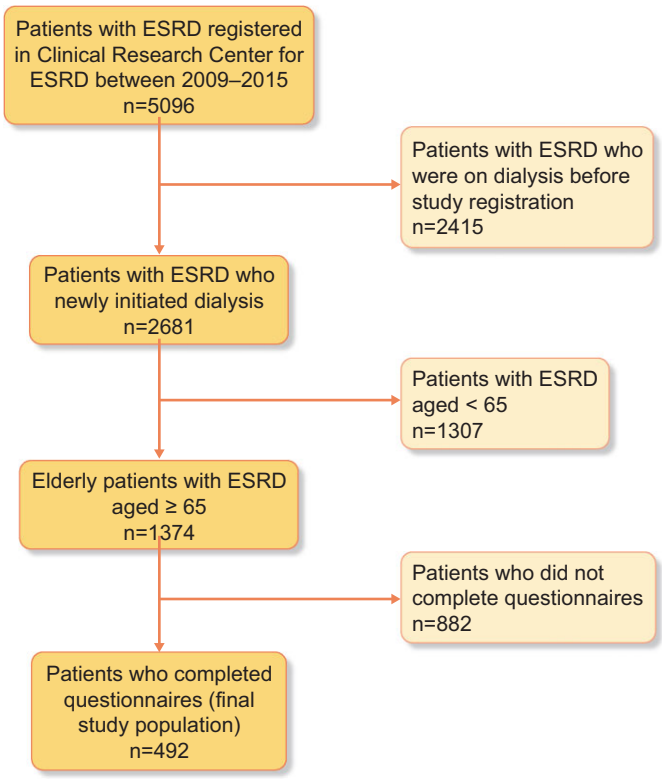


Figure 1: Study inclusion flow chart for 5096 patients with ESRD (flow diagram of the study protocol).

than whites, and Asians had higher PCS scores than whites. A Korean cohort study also demonstrated a relationship between QOL and mortality in patients with ESRD [15]. Studies on QOL have yielded inconclusive findings regarding the comparative impact of different dialysis modalities on QOL domains [16–18]; however, understanding the influence of modality on QOL is an important factor in modality selection.

The elderly population has a high prevalence of chronic diseases such as hypertension, diabetes, heart disease and lung disease [19]. Decreased muscle mass reduces their physical activity compared with the general population [20–22]. In addition, elderly dialysis patients have more cognitive impairment than younger people [23–26]. The combined physical and mental health problems may decrease QOL in the elderly [19].

It is important to investigate the impact of QOL on survival as the number of elderly patients with ESRD is increasing. However, the relationship between QOL and long-term prognosis has not been sufficiently studied specifically in elderly ESRD patients. Comparative studies on the QOL according to the dialysis modality in elderly dialysis patients are also limited [27, 28]. We aimed to analyze the association between QOL and mortality in elderly ESRD patients and clarify which QOL domains could affect patient deaths.

MATERIALS AND METHODS

Study design and participants

The Clinical Research Center for ESRD (CRC for ESRD) cohort is a nationwide, multicenter, web-based, prospective cohort of ESRD patients undergoing dialysis in 31 hospitals in South Korea (NCT00931970). The study cohort has been previously described [29, 30]. The current study included 492 patients with ESRD, from the CRC for ESRD cohort study, who had newly initiated dialysis, completed QOL questionnaires, and were 65 years or older between July 2009 and June 2015 (Fig. 1). These patients were followed up until December 2019. Dialysis modality was defined as the modality 3 months after the first dialysis or the modality was defined at dialysis initiation if death occurred before 3 months. Informed consent was obtained from all patients and they participated voluntarily. The study protocol was approved by the Institutional Review Board of each center, and the study was conducted in accordance with the 2013 Declaration of Helsinki.

Data collection

All data were registered in a web-based CRC for ESRD database. They were selectively extracted for analysis in this study. The baseline information collected included age, sex, height, weight, body mass index, primary renal disease, comorbid disease, modified Charlson comorbidity index (mCCI) and laboratory data. The laboratory data are the value at the start of dialysis. The mCCI was calculated for each patient at dialysis initiation [31, 32]. The estimated glomerular filtration rate (eGFR) was calculated using the Modification of Diet in Renal Disease study group equation [33]. The main outcome was the survival rate of elderly ESRD patients after dialysis initiation.

Survey instruments

To evaluate the QOL of ESRD patients, we used the Korean version of the Kidney Disease Quality of Life Short Form 1.3 (KDQOL-SF 1.3), a self-reported specific questionnaire [34]. Its validity of QOL assessment using KDQOL-SF 1.3 in patients with ESRD has

Table 1: Baseline characteristics according to PCS and MCS.

Variable	Overall ($n = 492$)	PCS		P-value	MCS		P-value
		Lower group ($n = 247$)	Higher group ($n = 245$)		Lower group ($n = 246$)	Higher group ($n = 246$)	
Age (years)	74.3 ± 6.8	75.8 ± 6.8	72.9 ± 6.4	<.001	74.6 ± 6.7	74.0 ± 6.9	.318
Sex (% male)	308 (62.6)	139 (56.3)	169 (69.0)	.004	153 (62.2)	155 (63.0)	.852
BMI (kg/m^2)	23.2 ± 3.5	23.0 ± 3.7	23.3 ± 3.2	.396	23.1 ± 3.5	23.3 ± 3.5	.524
Dialysis type							
HD	378 (77.0)	193 (78.1)	185 (75.8)	.592	190 (77.2)	188 (76.7)	.915
PD	113 (23.0)	54 (21.9)	59 (24.2)		56 (22.8)	57 (23.3)	
Primary renal disease, *n* (%)							
Diabetes	300 (61.0)	161 (65.2)	139 (56.7)	.091	151 (61.4)	149 (60.6)	.451
Hypertension	77 (15.7)	39 (15.8)	38 (15.5)		33 (13.4)	44 (17.9)	
Glomerulonephritis	38 (7.7)	13 (5.3)	25 (10.2)		19 (7.7)	19 (7.7)	
Others	77 (15.7)	34 (13.8)	43 (17.6)		43 (17.5)	34 (13.8)	
Comorbid conditions, *n* (%)							
Diabetes	322 (65.5)	173 (70.0)	149 (60.8)	.032	163 (66.3)	159 (64.6)	.705
Congestive heart failure	84 (17.1)	50 (20.2)	34 (13.9)	.061	43 (17.5)	41 (16.7)	.811
Coronary artery disease	100 (20.3)	64 (25.9)	36 (14.7)	.002	55 (22.4)	45 (18.3)	.263
Peripheral vascular disease	55 (11.2)	41 (16.6)	14 (5.7)	<.001	29 (11.8)	26 (10.6)	.668
Arrhythmia	17 (3.5)	10 (4.1)	7 (2.9)	.469	11 (4.5)	6 (2.4)	.217
Cerebrovascular disease	60 (12.2)	44 (17.8)	16 (6.5)	<.001	38 (15.5)	22 (8.9)	.028
Chronic lung disease	40 (8.1)	23 (9.3)	17 (6.9)	.336	25 (10.2)	15 (6.1)	.099
Peptic ulcer disease	35 (7.1)	20 (8.1)	15 (6.1)	.394	13 (5.3)	22 (8.9)	.115
Moderate or severe liver disease	15 (3.1)	5 (2.0)	10 (4.1)	.185	7 (2.9)	8 (3.3)	.793
Connective tissue disease	88 (17.9)	43 (17.4)	45 (18.4)	.782	43 (17.5)	45 (18.3)	.814
Malignancy	42 (8.5)	21 (8.5)	21 (8.6)	.978	22 (8.9)	20 (8.1)	.747
mCCI	6.36 ± 2.05	6.78 ± 2.07	5.93 ± 1.94	<.001	6.27 ± 2.13	6.14 ± 1.94	.020
Smokers, *n* (%)							
Non-smoker	263 (54.2)	139 (57.4)	124 (51.0)	.255	141 (57.8)	122 (50.6)	.252
Smoker	40 (8.3)	21 (8.7)	19 (7.8)		20 (8.2)	20 (8.3)	
Ex-smoker	182 (37.5)	82 (33.9)	100 (41.2)		83 (34.0)	99 (41.1)	
Systolic BP (mmHg)	143.1 ± 21.9	142.5 ± 22.2	143.8 ± 21.6	.517	143.6 ± 21.1	142.6 ± 22.7	.634
Diastolic BP (mmHg)	75.1 ± 12.4	74.3 ± 12.1	75.9 ± 12.7	.158	75.0 ± 12.2	75.3 ± 12.6	.817
Residual urine volume ($n = 298$), *n* (%)							
≥100 mL/day	252 (84.6)	130 (83.3)	122 (85.9)	.538	119 (83.2)	133 (85.8)	.537
<100 mL/day	46 (15.4)	26 (16.7)	20 (14.1)		24 (16.8)	22 (14.2)	
Laboratory data							
Hemoglobin (g/dL)	9.2 ± 1.5	9.2 ± 1.5	9.1 ± 1.5	.662	9.3 ± 1.5	9.1 ± 1.4	.186
Albumin (g/dL)	3.4 ± 0.6	3.3 ± 0.7	3.5 ± 0.5	.008	3.3 ± 0.7	3.4 ± 0.5	.051
Blood urea nitrogen (mg/dL)	81.6 ± 35.4	78.1 ± 37.7	85.1 ± 32.7	.028	78.0 ± 35.9	85.2 ± 34.7	.024
Creatinine (mg/dL)	7.7 ± 3.0	7.3 ± 2.8	8.1 ± 3.2	.001	7.5 ± 3.0	7.8 ± 3.0	.135
eGFR (mL/min/1.73 m^2)	7.8 ± 3.4	8.3 ± 3.5	7.7 ± 3.2	.033	8.2 ± 3.4	7.8 ± 3.4	.132
CRP (mg/dL)	0.5 (0.1–2.0)	0.6 (0.1–2.4)	0.4 (0.1–1.5)	.014	0.6 (0.1–2.3)	0.4(0.1–1.5)	.125
Total cholesterol (mg/dL)	150.0 ± 44.1	152.4 ± 46.4	147.5 ± 41.7	.255	153.7 ± 48.5	146.4 ± 38.1	.089
Triglycerides (mg/dL)	119.9 ± 56.2	123.7 ± 58.6	116.1 ± 53.6	.196	124.6 ± 59.9	115.7 ± 52.5	.131
LDL (mg/dL)	84.4 ± 34.4	86.5 ± 35.9	82.0 ± 32.6	.226	86.2 ± 37.1	82.7 ± 31.6	.344
Ferritin (ng/dL)	213.0 (116.1–373.2)	243.8 (112.8–395.5)	190.7 (116.4–357.9)	.126	243.3 (119.0–396.4)	196.6 (114.1–349.9)	.091
Calcium (mg/dL)	8.0 ± 0.9	8.0 ± 0.9	8.0 ± 1.0	.853	8.0 ± 0.9	8.0 ± 1.0	.592
Phosphate (mg/dL)	5.2 ± 1.6	5.2 ± 1.7	5.2 ± 1.4	.960	5.1 ± 1.7	5.2 ± 1.5	.258
Uric acid (mg/dL)	7.8 ± 2.5	7.7 ± 2.7	7.9 ± 2.4	.294	7.6 ± 2.5	8.0 ± 2.5	.049
Intact PTH (mg/dL)	227.6 ± 179.2	210.0 ± 163.2	246.5 ± 193.6	.031	225.7 ± 190.4	229.4 ± 168.5	.397

Data are presented as mean ± standard deviation, median (interquartile range) or *n* (%).
BMI, body mass index; BP, blood pressure.

been previously confirmed [35]. Information about the QOL was gathered at 3 months after dialysis initiation. This questionnaire consists of 80 items in 19 domains plus 1 separate. The questionnaire survey takes approximately 15 min to complete, making it suitable for use in clinical settings. Each domain is scored on a scale of 0–100, with higher scores reflecting a better QOL.

KDQOL is divided into a KDCS and Short Form (SF)-36. The score of the ESRD-targeted items is aggregated into the KDCS score. The SF-36 score, which evaluates overall health status, is the sum of the PCS and MCS scores. The PCS includes items related to physical functioning, physical roles, pain and general health, while the MCS includes items related to emotional roles, emotional well-being, emotional energy and social functioning.

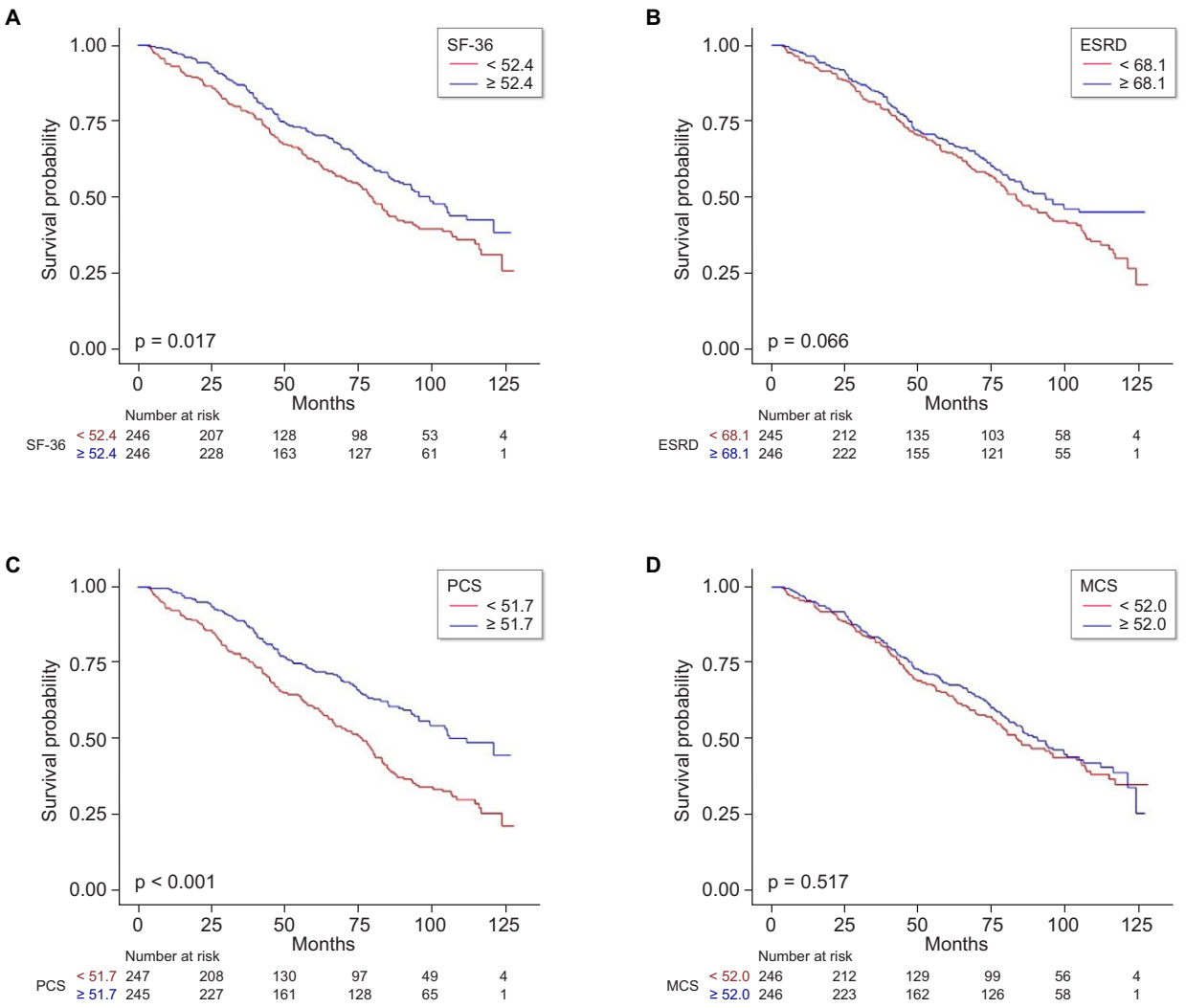


Figure 2: Kaplan–Meier curve mortality analysis according to QOL domain.

Statistical analysis

We compared sociodemographic, clinical and biochemical data using Pearson's chi-square or Fisher's exact test for categorical variables and the Student's *t*-test for continuous variables. Continuous variables were expressed as the mean and standard deviation. Mortality analysis was performed using the Kaplan–Meier survival graph. We performed multivariable Cox analysis, adjusting for age, sex, mCCI, albumin, creatinine, C-reactive protein (CRP), uric acid and intact parathyroid hormone (PTH). The factors associated with the PCS score were evaluated with linear regression analysis and the significantly different factors were included in the multivariable analysis. Statistical analysis was performed using IBM SPSS Statistics software (version 22.0; IBM Corp., Armonk, NY, USA) and R software (R Foundation for Statistical Computing, Vienna, Austria; www.r-project.org). *P*-values of $<.05$ were considered statistically significant.

RESULTS

Baseline characteristics

Before conducting the original analysis, baseline characteristics were compared between patients who completed questionnaires (CQ) and those who did not complete questionnaires (non-CQ) to examine potential biases (Supplementary data, Table S1). The Kaplan–Meier curve revealed that there was no difference in survival rate between the CQ and non-CQ groups ($P = .242$, Supplementary data, Fig. S1). Univariable and multivariable Cox regression analyses showed comparable mortality between two groups (Supplementary data, Table S2). It suggests that the enrolled patients with the questionnaire survey were not biased from the total patients in terms of mortality.

The baseline characteristics of the enrolled patients are summarized in Table 1. The mean age was 74.3 years and 308 (62.6%) were male. The primary causes of ESRD were diabetes in 300 (61%) and hypertension in 77 (15.7%). At the start of dialysis, the mean eGFR was 7.8 ± 3.4 mL/min/1.73 m^2. Of the patients, 378 (77.0%) were on hemodialysis (HD) and 113 (23.0%) were on peritoneal dialysis (PD). The patients were allocated to lower or higher score groups according to the four QOL domains of SF-36, ESRD-targeted items, PCS and MCS.

Table 1 compares the PCS and MCS groups by dividing them into median values. The higher PCS group included younger patients. Comorbidity evaluated by the mCCI was significantly less common in the higher score PCS and MCS groups ($P < .001$ and $P = .020$, respectively). Among the laboratory data, albumin,

Table 2: Associations of QOL domains and mortality in Cox regression analysis.

	Univariable analysis		Multivariable analysis					
			Model 1		Model 2		Model 3	
	HR (95% CI)	*P*-value	HR (95% CI)	*P*-value	HR (95% CI)	*P*-value	HR (95% CI)	*P*-value
SF-36								
<51.3 (reference)	1		1		1		1	
≥51.3	0.74 (0.57–0.95)	0.018[a]	0.81 (0.63–1.05)	0.105	0.88 (0.68–1.14)	0.348	0.85 (0.63–1.15)	0.289
ESRD-targeted item								
<68.1 (reference)	1		1		1		1	
≥68.1	0.79 (0.62–1.02)	0.066	0.84 (0.65–1.07)	0.159	0.88 (0.68–1.13)	0.315	0.84 (0.62–1.13)	0.239
PCS								
<51.5 (reference)	1		1		1		1	
≥51.5	0.56 (0.43–0.72)	<0.001[a]	0.63 (0.48–0.82)	<0.001[a]	0.70 (0.53–0.91)	0.008[a]	0.71 (0.52–0.97)	0.031[a]
MCS								
<51.0 (reference)	1		1		1		1	
≥51.0	0.92 (0.72–1.18)	0.516	1.01 (0.78–1.30)	0.946	1.07 (0.83–1.38)	0.613	1.07 (0.79–1.44)	0.661

[a]P for trend.
Model 1: adjusted for age and sex.
Model 2: Model 1 + mCCI.
Model 3: Model 2 + albumin, creatinine, CRP, uric acid and intact PTH.

blood urea nitrogen, creatinine, eGFR, CRP and intact PTH differed between the two PCS groups. The baseline characteristics according to SF-36 and ESRD-targeted items are shown in Supplementary data, Table S3.

Survival rate in each QOL domain

The overall mean follow-up duration after dialysis initiation was 67.3 months. The Kaplan–Meier curve analysis revealed that the higher SF-36 and PCS groups had significantly better survival rates ($P = .017$ and $P < .001$, respectively), while the ESRD-targeted items and MCS score had no difference in survival rate (Fig. 2).

Univariable and multivariable Cox regression analyses of QOL are shown in Table 2. In the univariable analysis, higher SF-36 and PCS scores were significantly associated with better survival [SF-36: hazard ratio (HR) 0.74; 95% confidence interval (CI) 0.57–0.95; $P = .018$, PCS: HR 0.56; 95% CI 0.43–0.72; $P < .001$]. Multivariable Cox regression analysis confirmed that only the PCS score was an independent factor for patient death (Model 3: HR 0.71; 95% CI 0.52–0.97; $P = .031$). Linear regression analysis showed that age, sex, mCCI, albumin and intact PTH were associated with PCS (Table 3).

Survival rate in each PCS item

The four PCS score items were compared between the lower and higher PCS groups. All PCS item scores were significantly higher in the higher PCS group (all $P < .05$, Fig. 3).

The Kaplan–Meier curve analysis revealed that higher physical functioning and pain scores showed better survival than in the corresponding lower groups ($P < .001$ and $P = .008$, respectively, Fig. 4). The univariable and multivariable Cox regression analyses of PCS items are shown in Table 4. Of the four PCS items, physical functioning and pain scores were significantly associated with patient death (physical functioning: HR 0.52; 95% CI 0.40–0.67; $P < .001$, pain: HR 0.71; 95% CI 0.56–0.92; $P = .008$) in the univariable analysis. Multivariable Cox regression analysis showed physical functioning to be an independent risk factor for survival (Model 3: HR 0.67; 95% CI 0.48–0.93; $P = .017$).

Table 3: Factors: associated with PCS in the linear regression model.

	Univariable analysis			Multivariable analysis		
	B (SE)	β	*P*-value	B (SE)	β	*P*-value
Age	−0.77 (0.14)	−0.24	<.001[a]	−0.45 (0.16)	−0.14	.005[a]
Sex	7.39 (1.99)	0.17	<.001[a]	6.63 (2.13)	−0.15	.002[a]
BMI	0.26 (0.28)	0.04	.350			
mCCI	−2.87 (0.46)	−0.27	<.001[a]	−2.00 (0.54)	−0.19	.000[a]
Albumin	6.01 (1.64)	0.16	<.001[a]	4.52 (1.69)	0.13	.008[a]
Creatinine	1.27 (0.32)	0.17	<.001[a]	0.35 (0.35)	0.05	.314
CRP	−0.11 (0.09)	−0.06	.209			
Uric acid	0.56 (0.39)	.07	0.151			
Intact PTH	0.02 (0.01)	.14	0.006[a]	0.01 (0.01)	0.08	.085

[a]P for trend.
BMI, body mass index; SE, standard error.

DISCUSSION

We investigated the impact of QOL on the long-term survival of elderly ESRD patients using enrollees from a Korea nationwide prospective cohort. Among the QOL domains, a low PCS score was associated with a lower survival rate. The effect of PCS on survival was still significant after adjusting for confounding factors. Elderly ESRD patients with high comorbidity levels or low albumin levels had lower PCS scores. Among the PCS items, only physical functioning was significantly associated with mortality. This study suggests that the physical component could be an important predictor for the survival of elderly ESRD patients.

The impact of QOL has not been sufficiently studied specifically in elderly ESRD patients. As the number of aging people is increasing worldwide, more attention should be paid to elderly ESRD patients in clinical practice. It is important to study their prognostic factors regarding survival. Several studies have investigated QOL in elderly patients with ESRD [36–39]. In a cross-sectional study, Shah *et al.* [40] found a lower QOL in elderly ESRD patients aged >75 years managed on dialysis than in those with comprehensive conservative care. In addition, there were studies on changes in QOL before and after dialysis in elderly patients [41–43]. Trbojevic *et al.* [44] reported that elderly

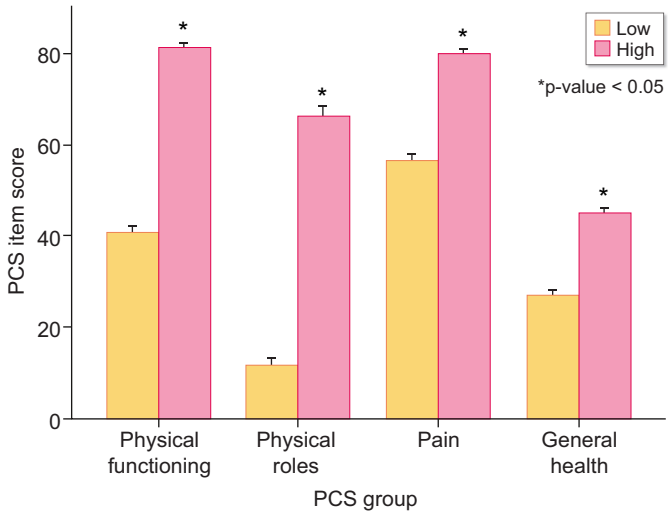


Figure 3: Comparison of each PCS item score.

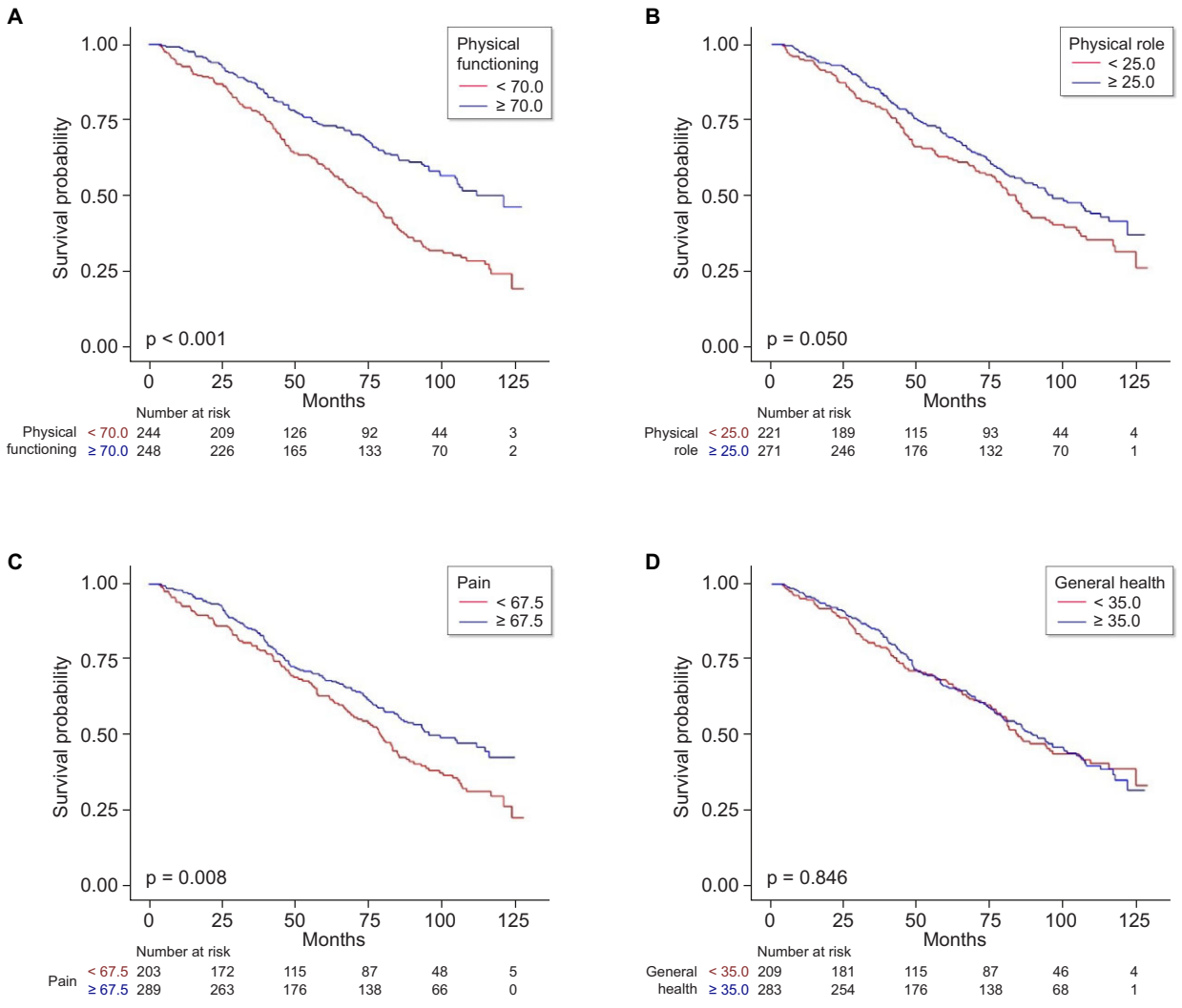


Figure 4: Kaplan–Meier curve mortality analysis according to PCS item.

Table 4: Associations of PCS items and mortality in Cox regression analysis.

			Multivariable analysis					
	Univariable analysis		Model 1		Model 2		Model 3	
	HR (95% CI)	*P*-value	HR (95% CI)	*P*-value	HR (95% CI)	*P*-value	HR (95% CI)	*P*-value
Physical functioning								
<70.0 (reference)	1		1		1		1	
≥70.0	0.52 (0.40–0.67)	<.001[a]	0.58 (0.44–0.76)	<.001[a]	0.62 (0.47–0.82)	<.001[a]	0.67 (0.48–0.93)	.017[a]
Physical roles								
<25.0 (reference)	1		1		1		1	
≥25.0	0.78 (0.61–1.00)	.051	0.79 (0.62–1.02)	.069	0.93 (0.72–1.21)	.606	0.93 (0.69–1.26)	.641
Pain								
<67.5 (reference)	1		1		1		1	
≥67.5	0.71 (0.56–0.92)	.008[a]	0.80 (0.62–1.03)	.088	0.84 (0.65–1.09)	.191	0.96 (0.70–1.30)	.769
General health								
<35.0 (reference)	1		1		1		1	
≥35.0	0.98 (0.76–1.26)	.846	0.92 (0.71–1.18)	.496	1.08 (0.83–1.40)	.581	1.13 (0.84–1.53)	.414

[a]P for trend.
Model 1: adjusted for age and sex.
Model 2: Model 1 + mCCI.
Model 3: Model 2 + albumin, creatinine, CRP, uric acid and intact PTH.

patients on PD had a worse appetite and mood than did younger adults. In the present study, the QOL domains PCS and SF-36 showed significant demographic differences in the score index, but ESRD-targeted items showed no difference according to score classification. For example, the mean age was higher in the lower PCS and SF-36 groups, whereas there was no difference between the lower and higher groups in the ESRD-targeted area. The ESRD-targeted items included questions on thoughts about kidney disease, its impact on daily life, sexual function, sleep problems, and the patient's satisfaction with dialysis staff encouragement and social support. For that reason, it appears that the ESRD-related area has few age-related differences in elderly patients.

There are several studies of QOL in elderly ESRD patients, but there are few on the relationship between QOL and prognosis. The associations between mortality and traditional risk factors for death such as body mass index, lipid abnormalities and hypertension differ between the elderly and general population [45–48]. Similarly, the association between QOL and mortality may be different in elderly ESRD patients compared with the general ESRD patient population. A prospective study in New Zealand investigating the health-related QOL of elderly ESRD patients [49] reported that initial disability and QOL could be useful in predicting disability after 12 months. Recently, a randomized controlled trial analyzed the relationship between the QOL domains and 2-year mortality in three groups including patients aged <65 years, 65–74 years and >75 years. Among the QOL domains, physical functioning, emotional health and social functioning were associated with 2-year mortality independent of age in HD patients [50]. Bastos *et al.* [51] reported that some QOL components are associated with mortality in dialysis patients and suggested that timely intervention measures aiming to enhance the QOL are an essential component to improving the dialysis patients' mortality. However, this study did not focus on elderly dialysis patients or evaluate long-term mortality. Unlike previous studies, our study analyzed a cohort of elderly patients with a mean age of 74.3 years and investigated the association between QOL domains and long-term prognosis. We identified significant results from several QOL domains and long-term mortality data collected through the Korea nationwide prospective ESRD cohort. The study showed that low PCS and SF-36 scores were associated with high mortality, while the MCS and ESRD-targeted item scores showed no correlation. Multivariable Cox regression analysis confirmed that only PCS was a risk factor for mortality in this study.

Previous studies have shown that PCS is a prognostic factor in patients with ESRD [51–53]. This is consistent with a previous prospective cohort study conducted in Taiwan, which reported that only a poor physical dimension in QOL domains was a strong predictor of mortality in 888 stable HD patients. Conversely, psychological depression does not predict mortality [8]. Pei *et al.* [54] reported that a lower PCS was associated with an increased mortality risk, whereas MCS was not. Dobronravov *et al.* [52] reported that PCS was independently related to all-cause mortality in 238 HD patients aged 18–64 years. Similarly, a Korean cohort study of 568 HD patients demonstrated that a low PCS correlates significantly with overall mortality [15]. Our study focused on the elderly patient over 65 years with ESRD and also showed that PCS is an important factor in the prognosis of elderly ESRD patients, consistent with previous studies.

The physical functioning component includes questions about strenuous and moderate activity, stair climbing, 200 m walking, 50 m walking and self-dressing. This item seems to be related to the prognosis because it evaluates physical performance. In the present study, patients with lower PCS are characterized by older age, more comorbid conditions and lower albumin. The linear regression analysis confirmed the correlation between these factors and PCS. Therefore, PCS may be regarded as a comprehensive marker reflecting not only chronological age but also coexisting diseases and nutritional status. Furthermore, our study suggests that the physical performance of elderly ESRD patients could be an important predictor related to survival. Therefore, evaluation of the patient's physical functioning, and attention to exercise and rehabilitation might improve patient survival.

Despite these strengths, there are several limitations to this study. First, this was an observational study and there may be unmeasured confounding factors. However, we used a nationwide ESRD cohort with a relatively large number of patients and adjusted for several confounding factors. Second, this was a

subjective assessment of patients' physical activity with a questionnaire and subjective evaluations of physical activity may be an under- or overestimate. Third, we only analyzed the association between quality of life at 3 months after initiation of dialysis and prognosis. Further studies of QOL at different time points and its relevance to prognosis are warranted. Fourth, subgroup analysis according to dialysis modality could not be conducted due to insufficient patient number and events. A larger study may suggest that QOL could be a considerable factor in elderly patients when choosing a dialysis modality. Lastly, this study only included a Korean population. Considering international differences in QOL by race, caution should be taken when generalizing and applying our findings to other populations.

In conclusion, we found that low physical health status increases mortality in elderly ESRD patients. Physical function, in particular, was the important factor associated with death. In contrast, mental health status did not show significant association with mortality. This study showed the importance of QOL in elderly ESRD patients' long-term prognosis. Nephrologists should pay attention to the physical activity of elderly ESRD patients and educate them to improve their physical ability through regular monitoring.

SUPPLEMENTARY DATA

Supplementary data are available at *Clinical Kidney Journal* online.

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AUTHORS' CONTRIBUTIONS

Conceptualization: Y.-K.C., J.-H.L., J.-H.C. and Y.-L.K. Data curation: Y.H.J., H.-Y.J., J.-Y.C., S.-H.P., C.-D.K. and Y.-L.K. Investigation : J.-H.L., J.-H.C. and Y.-L.K. Formal analysis: Yu Y.-K.C., J.-H.L. and Y.-n.J. Funding acquisition: J.-H.C. Methodology: Y.H.J., J.-H.L., H.-Y.J., J.-Y.C., S.-H.P., C.-D.K. and J.-H.C. Visualization: Y.-K.C. and Y.-n.J. Writing—original draft: Y.-K.C. Writing—review and editing: Y.-K.C., J.-H.C. and Y.-L.K.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on reasonable request from the corresponding authors. The data are not publicly available due to privacy or ethical restrictions.

CONFLICT OF INTEREST STATEMENT

The authors declare no competing interests

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