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A new assessment scale for post-dialysis fatigue in hemodialysis patients

Hirotoshi Kodama[1*], Taisuke Togari[2], Yusuke Konno[3], Akira Tsuji[4], Akihiro Fujinoki[1], Saburou Kuwabara[1] and Tatsuo Inoue[1]

Introduction

Fatigue is a common symptom [1] in dialysis patients and is associated with an impaired health-related quality of life (HRQOL). Most hemodialysis patients experience fatigue and malaise after treatment [2]. Within 5 h after dialysis, resting or taking a nap is reported [3], and more than 80% of patients experience fatigue symptoms [4]. Jhamb et al. [5] defined the fatigue symptoms that occurred after dialysis as post-dialysis fatigue (PDF).

Unlike chronic fatigue syndrome, mental fatigue and physical fatigue, the factors and mechanisms underlying PDF remain unclear. The symptoms and severity of PDF are evaluated using various scales. In cases of PDF, to examine the subjective symptoms of patients themselves, it is useful to utilize patient-based outcomes.

However, in conventional PDF studies, the evaluation indices have not been uniform. First, in studies evaluating fatigue after dialysis based on the "time," "frequency," and "intensity" [2, 6, 7], the reliability and validity of the scales were not examined. Second, the recovery time [8] is not an index that measures PDF directly but instead an indirect indicator that measures the [1] "time to recover from hemodialysis." Third, the fatigue scale [9] does not measure true PDF but rather chronic fatigue experienced by dialysis patients.

Clarifying the relevant factors of PDF from among dialysis treatment factors, nutritional status, and physical health factors would be extremely useful. Reducing PDF would benefit both the physical health and prognosis of hemodialysis patients. However, no international guidelines have yet been established regarding the definition of and optimal method of measuring PDF.

The present study therefore assessed a new post-dialysis fatigue self-assessment scale (PDF scale), which was developed in five steps. In the first step, the definition of PDF was clarified, an item pool for the scale was developed, and an exploratory factor analysis was conducted and the content validity examined. In the second step, the reliability was considered from the viewpoint of internal consistency. In the third step, the convergence validity with existing PDF indices was considered. In the fourth step, the relationship between the new PDF scale was assessed, and physiological PDF-related factors were clarified. Furthermore, the validity of the composition concept was considered by comparing out a new scale with existing PDF indices. In the fifth step, the relevance of PDF to self-rated health was evaluated.

Preparation

Development of the PDF scale

Create item pool

To create items for the PDF scale, a post-dialysis interview was conducted in five maintenance hemodialysis patients with different severities. The item pool was collected using three anonymous questions. The first asked, "Are there any symptoms that develop after dialysis and then recover?" The second asked, "What exactly is that symptom?" The third question, which was asked while showing the patient a health card (basic life study, symptom list), was, "Are there any other applicable items?"

Fourteen items were extracted by the interviews according to the advice of dialysis specialist groups in order to ensure the content validity. Based on the opinion of the specialist group (dialysis specialist, kidney physician, dialysis room nurse, clinical engineering technician) and with reference to previous studies, PDF was defined as "a subjective fatigue syndrome that specifically occurs for about half a day immediately after undergoing hemodialysis therapy."

Construction of a new PDF scale

We asked the patients about symptoms that they notice from the end of dialysis treatment until bedtime, as follows: (1) fatigue, (2) general malaise, (3) feeling exhausted and weak, (4) Lightheadedness, (5) needing to lie down and take a nap or rest, (6) difficulty moving without taking

* Correspondence: hiro25@jcom.zaq.ne.jp
[1]Division of Blood Purification Center, Kamifukuoka General Hospital, 931 Fukuoka, Fujimino, Saitama 356-0011, Japan
Full list of author information is available at the end of the article

a nap or rest, (7) no appetite, (8) headache, (9) thoracic discomfort, (10) toothache, (11) leg cramps, (12) not wanting to move, (13) unmotivated to do anything, and (14) feel pain after dialysis and end up doing nothing all day. These 14 symptoms were evaluated on a 5-point scale, ranging from "very severe," "strongly agree" to "not at all," "absolutely not applicable." The score was then reversed for the analysis.

Methods

Sampling

The subjects for this study were 128 outpatients receiving chronic hemodialysis in six dialysis-related facilities in the southwestern part of Saitama Prefecture who consented to participate in the study. Those who agreed to answer and participate were given the questions.

The inclusion criteria were as follows: (a) > 20 years of age, (b) undergoing hemodialysis for at least 3 months, and (c) able to write and read the Japanese language fluently. The exclusion criteria were as follows: (a) pregnancy, (b) presence of malignancy, (c) undergoing fracture treatment, and (d) serious mobility or eye problems. The study was conducted from June to November 2016. The Open University of Japan ethics committees approved the study protocol (approval number 8).

Survey method

A text-based description of the research and consent form were distributed to the six dialysis-related facilities. After being informed about the purpose of the research, patients gave their written consent. They were also informed that their participation was voluntary.

Construct validity

The study participants completed four sets of fatigue assessment tools: the newly developed PDF scale, recovery time, visual analog scale (VAS), and the fatigue scale.

Measurement of PDF

Recovery time

Patients were asked, "How long does it take you to recover from a dialysis session?" [8]. The recovery time is an indirect indicator for measuring the "time to recover from hemodialysis." This response was obtained as a free description.

VAS

Patients were asked to plot their current fatigue on a straight line of 100 mm (score 0 [0 mm] = exhausted and cannot do anything, score 10 [100 mm] = do not feel fatigue at all). The score was reversed for the analysis.

Fatigue scale

The fatigue scale used 8 out of the 64 items of the questionnaire developed by Koyama [9]. This scale measures chronic fatigue on a 5-point Likert scale, with possible answers ranging from "feel a lot" to "don't feel it at all" in response to questions such as, "Feel so tired that I want to lie down at times," "Feel tired and lacking energy," "Become very tired after just a small amount of exercise or work," "Feel sluggish lately," "Lack physical energy recently," "Believe that how tired I've been recently is abnormal," "Feel general fatigue lately," and "Do not feel refreshed even after a night's sleep."

Measurement of physical health

Self-rated health

Self-rated health (SRH) was measured on a 5-point Likert scale, with possible answers ranging from "poor" to "excellent" in response to questions such as, "How is your present health?" SRH has been shown to affect survival rates controlled for objective health status [10, 11].

Life satisfaction

Life satisfaction was measured on a 5-point scale, with possible answers of "unsatisfactory," "rather unsatisfactory," "neither unsatisfactory nor satisfactory," "rather satisfactory," and "satisfactory" in response to questions such as, "Are you satisfied with your present life?"

Physical functioning

Physical functioning was measured on a 3-point scale, with possible answers ranging from "yes, limited a lot" to "no, not limited at all" in responses to topics such as, "Vigorous activities, such as running, lifting heavy objects, participating in strenuous sports," "Moderate activities, such as moving a table, pushing a vacuum cleaner, or playing sports," "Lifting or carrying groceries," "Climbing several flights of stairs," "Climbing one flight of stairs," "Bending, kneeling, or stooping," "Walking more than a mile," "Walking several blocks," "Walking one block," and "Bathing or dressing yourself" [12].

Chronic kidney disease-related symptoms

Chronic kidney disease-related symptoms were assessed on a 5-point scale, with possible answers ranging from "Not at all bothered" to "extremely bothered" in responses to topics such as, "sore muscles," "chest pain," "cramps," "itchy or dry skin," "shortness of breath," "faintness/dizziness," "lack of appetite," "feeling washed out or drained," "numbness in the hands or feet," "nausea," and "problems with dialysis access" [13].

Clinical data

In order to evaluate whether or not PDF affects dialysis treatment, we used several indicators, as described in

this section [1]. Survey items were basic patient information (age, gender, dialysis vintage), body mass index (BMI), dialysis conditions (dialysis session length, blood flow rate, ultrafiltration rate), and single-pool Kt/V. The serum albumin level was used in this study because it has been reported to affect fatigue levels [8].. C-reactive protein was used because the inflammatory response may be involved in PDF [7]. Hemoglobin was used because of a report that it is related to feelings of exhaustion [14]. Intradialytic weight loss [5], which is considered to be an influential factor in PDF, and change in systolic blood pressure (ΔSBP = pre SBP-post SBP) [1, 15], which influences the prognosis and is suggested to be related to PDF, were also used. Since fatigue symptoms affect the nutritional status, we used the normalized protein catabolic rate (nPCR) [16], which is important as a nutritional assessment and prognostic factor [5]. In a previous study, normalized protein nitrogen appearance < 0.8 g/kg/day was associated with greater mortality [17]. In addition, we used the geriatric nutritional risk index (GNRI), which is the nutritional disorder risk standard of dialysis patients [18].

Statistical analyses

Continuous variables were presented as the mean (standard deviation), and values not following a normal distribution were presented as the median (first quartile, third quartile). The factor analysis of the developed PDF scale was carried out by the main factor method (promax rotation), and the reliability coefficient was obtained by Cronbach's α. For the item-total correlation of the PDF scale, convergence validity was assessed by Spearman's method. Recovery time was examined by logarithm (log-recovery time). In the binomial logistic regression analysis with SRH as the objective variable, model 1 included the age, gender, complications of diabetes, cardiovascular disease, fatigue from pre-dialysis, and physical functioning. In model 2, the PDF scale score was input into model 1. Analyses were performed on a personal computer using the JMP software program, ver. 11 (SAS institute Inc., Cary, NC, USA). P values < 0.05 were considered significant.

Results

A total of 150 surveys were distributed to consenting hemodialysis patients; of these, 128 were collected (collection rate 85%), and 126 were effective. The 126 patients were 67.4% male and 32.6% female. The mean (standard deviation) age of patients was 66 (11) years old, and complications were 33% diabetes and 20% cardiovascular disease. Patients with fatigue from before they had started dialysis accounted for 43%. The SRH was "good" in 81%. The clinical characteristics of the patients are presented in Table 1.

Table 1 Clinical characterics of the patients

Number (M/F, %)	*n* = 126 (67.4/32.6)
Age (years)	66.0 (11.0)
Dialysis vintage (years)	7 (3, 12)
Comorbidities (%)	
Diabetes mellitus	31
Cardiovascular diseases	20
Fatigue from before the dialysis (%)	43
Hemodialysis time (h)	4.0 (0.5)
Body mass index (kg/m^2)	21.8 (3.2)
Intradialytic weight loss (% of body weight)	4.0 (1.4)
Ultrafiltration rate (mL/kg/h)	11.5 (3.7)
Cardio thoracic ratio (%)	49.8 (5.4)
Pre systolic blood pressure (mmHg)	148 (23)
Post systolic blood pressure (mmHg)	146 (23)
ΔSBP (mmHg)*	0.3 (− 10, 7.2)
Pre sodium (mEq/L)	139 (2.7)
Post sodium (mEq/L)	139 (1.7)
Blood urea nitrogen (mg/dL)	60.6 (14.2)
Serum creatinine (mg/dL)	10.7 (2.8)
Albumin (mg/dL)	3.6 (0.3)
C-reactive protein (mg/dL)	0.09 (0.05, 0.19)
Hemoglobin (g/dL)	10.9 (1.3)
Single-poor Kt/V	1.5 (0.3)
nPCR (g/kg/day)	0.86 (0.16)
GNRI	93.3 (6.0)
Physical functioning	68.0 (23.4)
Symptoms	81.2 (13.3)
Self-rated health (good, poor, %)	(81, 19)
Life satisfaction (good, poor, %)	(71, 29)
PDF scale	31.8 (11.0)
Recovery time (min)	120 (30, 330)
VAS (mm)	40.0 (25.4)
Fatigue scale	12.5 (3.5)

Values for continuous variables are given as mean (SD). Dialysis vintage, ΔSBP, c-reactive protein, and recovery time are given as median (Q1, Q3). **ΔSBP* Δsystolic blood pressure = (pre − post) SBP, *nPCR* normalized protein catabolic rate, *GNRI* geriatric nutritional risk index, *PDF scale* post dialysis fatigue scale

Reliability and validity of the PDF scale

We did not recognize a ceiling or floor effect for any of the 14 items. The items were calculated using a principal factor analysis with promax rotation. One factor was calculated as a result of a principal factor analysis with promax rotation (cumulative contribution rate; 51.08%, Cronbach's α; 0.924), and there was named as PDF scale. As "leg cramps" (load amount = 0.271) had a load amount below 0.35, it was excluded from the 14 items. The item-total correlation of the 13 items and the total

score showed a coefficient of ≥ 0.40 ($p < 0.001$) for all items (Table 2). In addition, the convergence validity of the PDF scale was significantly correlated with the recovery time ($r = 0.696$, $p < 0.001$), VAS ($r = 0.670$, $p < 0.001$), and fatigue scale ($r = 0.732$, $p < 0.001$).

Factors related to the PDF scale

There were no significant correlations between the all scales (PDF scale; $r = 0.107$, $p = 0.242$; log-recovery time; $r = -0.039$, $p = 0.675$; VAS; $r = 0.077$, $p = 0.414$; fatigue scale; $r = 0.154$, $p = 0.093$) and age. The correlation among the PDF scale, log-recovery time, VAS, fatigue scale, and each parameter was adjusted for age and gender. The PDF scale ($r = 0.221$, $p = 0.014$) and fatigue scale ($r = 0.180$, $p = 0.046$) showed a significant positive correlation with already suffering fatigue before dialysis. All fatigue scales showed a significant negative correlation with physical functioning (PDF scale; $r = -0.443$, $p < 0.001$; log-recovery time; $r = -0.360$, $p = 0.002$; VAS; $r = -0.295$, $p < 0.001$; fatigue scale; $r = -0.594$, $p < 0.001$) and symptoms related to chronic kidney disease ($r = -0.521$, $p < 0.001$; $r = -0.321$, $p = 0.001$; $r = -0.357$, $p = 0.001$; $r = -0.574$, $p < 0.001$; respectively), and a significant positive correlation was noted with SRH ($r = 0.430$, $p < 0.001$; $r = 0.311$, $p = 0.002$; $r = 0.285$, $p = 0.001$; $r = 0.380$, $p < 0.001$; respectively). The PDF scale ($r = 0.201$, $p = 0.018$) and fatigue scale ($r = 0.221$, $p = 0.022$) showed a significant positive correlation with life satisfaction, and the PDF scale ($r = 0.179$, $p = 0.045$) showed a significant positive correlation with hemoglobin (Table 3).

Table 4 shows the relationship between PDF and the nutritional status in patients ($n = 51$) with an nPCR < 0.8 (median), which is an indicator of protein intake. We considered patients with nPCR < 0.8 that were reported to have a poor prognosis. The PDF scale ($r = 0.288$, $p = 0.042$) and log-recovery time ($r = -0.445$, $p = 0.011$) showed a significant negative correlation with albumin, and the PDF scale ($r = -0.429$, $p = 0.002$), log-recovery time ($r = -0.333$, $p = 0.046$), and fatigue scale ($r = -0.407$, $p = 0.004$) showed a significant negative correlation with the nPCR.

Factors related to the PDF scale and SRH

Table 5 shows the results of the logistic regression analysis with SRH as the response variable. The explanatory variables of model 1 were age, gender, diabetes mellitus, cardiovascular diseases, fatigue suffered before dialysis, and physical functioning ($R^2 = 0.08$, AIC = 116.76), and no significant variables were recognized. In model 2, the PDF scale score was included in model 1, giving an $R^2 = 0.23$ and AIC = 102.16. The PDF scale score (odds ratio 1.13, 95% confidence interval 1.06–1.21) was therefore considered a significant explanatory variable of SRH.

Discussion

Reliability and validity of the PDF scale

We developed a new scale for directly measuring PDF of hemodialysis patients and examined the reliability and validity. The PDF scale was significantly correlated with the existing fatigue indices of recovery time ($r = 0.696$, $p < 0.001$), VAS ($r = 0.670$, $p < 0.001$), and fatigue scale ($r = 0.732$, $p < 0.001$). Therefore, the PDF scale showed a high convergence validity with the recovery time, VAS, and fatigue scale. Our attempts to develop a scale for directly measuring PDF produced a sufficiently clinically applicable scale.

Since there are no international guidelines on the PDF definition and measurement methods, we developed our

Table 2 Correlation of thirteen items and PDF scale score

No.	Contents	PDF scale	
		r	*p*
1	Fatigue	0.802	<0.001
2	General malaise	0.802	<0.001
3	Feel exhausted and weak	0.833	<0.001
4	Lightheadedness	0.726	<0.001
5	Need to lie down and take a nap or rest	0.791	<0.001
6	Difficulty moving without taking a nap or rest	0.839	<0.001
7	No appetite	0.463	<0.001
8	Headache	0.576	<0.001
9	Thoracic discomfort	0.52	<0.001
10	Toothache	0.436	<0.001
12	Do not want to move	0.844	<0.001
13	Unmotivated to do anything	0.815	<0.001
14	Following dialysis, feel pain and end up doing nothing all day	0.784	<0.001

PDF scale post dialysis fatigue scale

Table 3 Partial correlation between PDF scale, RT, VAS, Fatigue scale and each parameters (n = 126)

	PDF scale		log-RT		VAS		Fatigue scale	
	r	*p*	*r*	*p*	*r*	*p*	*r*	*p*
Dialysis vintage (years)	− 0.110	0.219	0.004	0.964	0.035	0.704	− 0.154	0.086
Diabetes mellitus	0.111	0.215	0.048	0.627	− 0.020	0.827	0.128	0.157
Cardiovascular diseases	− 0.078	0.382	− 0.080	0.425	0.118	0.198	0.151	0.092
Fatigue from before the dialysis	0.221	0.014	0.049	0.626	0.087	0.347	0.180	0.046
Body mass index (kg/m^2)	0.017	0.846	0.017	0.864	− 0.016	0.864	0.019	0.833
Intradialytic weight loss (% BW)	− 0.057	0.522	0.046	0.646	0.031	0.737	0.014	0.870
Ultrafiltration rate (mL/kg/h)	− 0.057	0.527	− 0.016	0.868	− 0.040	0.658	0.016	0.770
ΔSBP (mmHg)	− 0.008	0.390	− 0.140	0.122	− 0.211	0.010	− 0.005	0.954
Albumin (mg/dL)	− 0.011	0.722	− 0.101	0.639	0.001	0.910	0.071	0.567
C-reactive protein (mg/dL)	0.011	0.450	0.051	0.985	0.012	0.936	− 0.012	0.401
Hemoglobin (g/dL)	0.179	0.045	0.089	0.373	0.079	0.389	0.174	0.053
Single-poor Kt/V	− 0.009	0.317	− 0.010	0.771	0.052	0.621	0.040	0.241
nPCR (g/kg/day)	0.005	0.583	− 0.032	0.751	0.146	0.171	0.044	0.524
GNRI	0.054	0.418	− 0.033	0.836	− 0.053	0.652	0.093	0.187
Physical functioning	− 0.443	<0.001	− 0.360	0.002	− 0.295	<0.001	− 0.594	<0.001
Symptoms	− 0.521	<0.001	− 0.321	0.001	− 0.357	0.001	− 0.574	<0.001
Self-rated health	0.430	<0.001	0.311	0.002	0.285	0.001	0.380	<0.001
Life satisfaction	0.201	0.018	0.132	0.226	0.104	0.215	0.221	0.022

Adjusted for age and gender. The correlation was calculated in the pairwise deletion. *PDF scale* post dialysis fatigue scale, *RT* recovery time, *ΔSBP* Δsystolic blood pressure = pre − post SBP, *nPCR* normalized protein catabolic rate, *GNRI* geriatric nutritional risk index

Table 4 Partial correlation between PDF scale, RT, VAS, Fatigue scale and each parameters in nPCR less than 0.8 (n = 51)

	PDF scale		log-RT		VAS		Fatigue scale	
	r	*p*	*r*	*p*	*r*	*p*	*r*	*p*
Dialysis vintage (years)	− 0.213	0.135	0.046	0.806	0.074	0.688	− 0.168	0.236
Diabetes mellitus	0.241	0.098	0.195	0.269	− 0.116	0.452	0.156	0.293
Cardiovascular diseases	− 0.034	0.803	0.043	0.801	0.342	0.019	− 0.043	0.812
Fatigue from before the dialysis	0.115	0.421	0.099	0.590	0.198	0.162	0.053	0.609
Body mass index (kg/m^2)	0.081	0.611	0.112	0.567	0.075	0.664	0.002	0.985
Intradialytic weight loss (% BW)	− 0.152	0.328	− 0.258	0.191	− 0.133	0.428	− 0.168	0.285
Ultrafiltration rate (mL/kg/h)	− 0.161	0.284	− 0.182	0.312	− 0.179	0.289	− 0.117	0.462
ΔSBP (mmHg)	0.195	0.351	0.097	0.633	− 0.081	0.733	− 0.050	0.458
Albumin (mg/dL)	− 0.288	0.042	− 0.445	0.011	− 0.158	0.278	0.077	0.626
C-reactive protein (mg/dL)	0.230	0.365	0.442	0.078	0.669	0.047	− 0.176	0.577
Hemoglobin (g/dL)	0.192	0.189	0.199	0.211	0.209	0.177	0.201	0.163
Single-poor Kt/V	− 0.101	0.523	− 0.190	0.388	− 0.184	0.289	− 0.091	0.604
nPCR (g/kg/day)	− 0.429	0.002	− 0.333	0.046	0.014	0.870	− 0.407	0.004
GNRI	− 0.041	0.745	− 0.332	0.051	− 0.293	0.068	0.087	0.589
Physical functioning	− 0.543	< 0.001	− 0.528	0.002	− 0.226	0.142	− 0.551	< 0.001
Symptoms	− 0.570	< 0.001	− 0.286	0.114	− 0.199	0.260	− 0.547	< 0.001
Self-rated health	0.244	0.072	0.285	0.166	− 0.096	0.769	0.449	0.001
Life satisfaction	0.288	0.039	0.130	0.578	− 0.063	0.777	0.362	0.015

Adjusted for age and gender. The correlation was calculated in the pairwise deletion. *PDF scale* post dialysis fatigue scale, *RT* recovery time, *ΔSBP* Δsystolic blood pressure = pre − post SBP, *nPCR* normalized protein catabolic rate, *GNRI* geriatric nutritional risk index

Table 5 Results of logistic regression analysis with the self-rated health (good vs poor) as dependent

Variables	Model 1			Model 2		
	OR	95% CI	*p*	OR	95% CI	*p*
Age (years)	0.97	(0.93–1.01)	0.184	0.98	(0.92–1.03)	0.335
Gender						
Male (ref.)	1			1		
Female	1.04	(0.34–2.91)	0.946	1.05	(0.30–3.45)	0.931
Diabetes mellitus						
No diabetes (ref.)	1			1		
Diabetes	1.02	(0.32–3.02)	0.966	0.97	(0.27–3.29)	0.963
Cardiovascular diseases						
No cardiovascular diseases (ref.)	1			1		
Cardiovascular diseases	0.75	(0.19–2.43)	0.649	1.31	(0.30–5.14)	0.707
Fatigue from before the dialysis						
No (ref.)	1			1		
Yes	1.73	(0.60–4.90)	0.302	0.97	(0.29–3.12)	0.966
Physical functioning	0.97	(0.95–1.00)	0.017	1	(0.97–1.03)	0.775
PDF scale score				1.13	(1.06–1.21)	<0.001
R^2	0.08			0.23		
AIC	116.76			102.16		

Values are given as OR (95% confidence interval). *OR* odds ratio, *PDF scale score* post dialysis fatigue scale score

new scale to directly PDF. As a result of our factor analysis, the PDF scale comprising 13 items had a high validity (α = 0.924). Therefore, the contents defined in the present study were considered to be reasonable.

Factors related to the PDF scale

Higher PDF scale and fatigue scale scores were associated with fatigue already present before dialysis. The presence of fatigue from before dialysis started was considered to reflect not only PDF but also chronic fatigue. Therefore, the PDF scale may not clearly reflect the PDF. However, PDF is an influencing factor for ESRD-related fatigue [5]. Therefore, we must consider whether the PDF scale really can detect PDF. Although a previous study stated that fatigue can be expected to improve due to an increase in the hemoglobin value [14], we did not observe this in the present study. Therefore, the PDF scale may not clearly reflect the PDF.

There were also no significant correlations between the PDF scale and intradialytic weight loss. Patients with excessive intradialytic weight gain tend to receive a higher ultrafiltration rate [19]. In a previous study, a longer recovery time was associated with a greater intradialytic weight loss [15], suggesting that the ultrafiltration volume may play a role in causing PDF. In addition, self-reported fatigue was associated with a particularly low mean arterial blood pressure post-dialysis [20]. The "stress" reaction accompanying intradialytic hypotension may also contribute to the development of PDF [1]. In the subjects of the present study, the ΔSBP was small compared to the intradialytic weight loss. It was intended for outpatients, it may have selected a high-quality patient. Therefore, it is necessary to consider that the dry weights are appropriate. In this regard, it is necessary to consider each patient's brain natriuretic peptide and human atrial natriuretic peptide, which is a subject to be studied in the future.

A high value on the PDF scale reflected a reduced physical functioning. This result was similar to that reported by Lindsay et al. [8]. PDF was thought to influence the physical functioning of hemodialysis patients, even after adjusting for age and gender. A high value on the PDF scale was shown to be associated with worse chronic kidney disease-related symptoms, SRH, and life satisfaction. A previous study reported an association between physical functioning and an individual's general health [8, 15]. Based on the present findings, PDF was suggested to be an important factor influencing various symptoms as well as the SRH and life satisfaction in hemodialysis patients.

In patients with an nPCR < 0.8, the nPCR and serum albumin decreased as the PDF scale increased. In addition, a high value on the PDF scale was shown to be associated with a reduced physical functioning, exacerbated chronic kidney disease-related symptoms, and a poor life satisfaction. It has been reported that the nutritional indicators of nPCR and serum albumin are associated with patient mortality risk [21, 22]. Treating

depressive symptoms has been reported to improve the nPCR and serum albumin levels [23]. However, the present study did not consider the mental factors of patients, so a future study will need to evaluate the mental health of subjects. Nevertheless, the present findings indicate that the PDF scale has high construct validity.

In the logistic regression analysis with SRH as the objective variable, a high PDF scale score was shown to reduce SRH. In previous studies, the recovery time was reportedly longer for patients with a poor quality of life than in those with a good quality of life [8, 24]. Therefore, PDF is suggested to be an important factor influencing SRH among hemodialysis patients.

Fatigue negatively impacts the health-related quality of life and is associated with both increased morbidity and mortality in patients suffering from many chronic illnesses [20]. However, only a few studies have been specifically designed and conducted to evaluate treatments for PDF. Proposed treatment methods include managing the sodium concentration [15], delivering low-temperature dialysate [25], and encouraging walking [26] and exercise [27, 28]. These small studies were not prospective, randomized, or controlled. The causes and pathogenesis of PDF are unclear at present. However, since PDF is a risk factor influencing the quality of life and mortality expectancy, it must be dealt with promptly. PDF is suggested to influence the physical health of hemodialysis patients and is an important factor that must be considered in patient care.

Limitations and future work

First, this study involved a small number of subjects. Second, the patient population was restricted to those in the southwestern part of Saitama Prefecture. Third, this study was intended for outpatients, it may have selected a high-quality patient. Fourth, this study design was cross-sectional. In the future, it will be necessary to expand and investigate more patients from other regions. Therefore, we should conduct follow-up surveys and assess the predictive validity and test-retest reliability. In addition, in order to consider the relationship between PDF and the prognosis, it will be necessary to consider the utility of the PDF scale as a screening tool.

Conclusion

We developed a new scale for directly measuring PDF of hemodialysis patients and examined its influencing factors. The new PDF scale showed convergence validity with the existing fatigue scales. PDF is a major factor affecting SRH.

Abbreviations

GNRI: Geriatic nutritional risk index; nPCR: Normalized protein catabolic rate; PDF: Post-dialysis fatigue; SBP: Systolic blood pressure; SRH: Self-rated health

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Ethics approval and consent participate

This study was conducted in accordance with the guidelines of the Declaration of Helsinki and approved by the ethics committees of The Open University of Japan (approval number 8). Written informed consent was obtained from the patients.

Authors' contributions

HK designed the study and contributed to the data collection, data analysis, drafting of the manuscript, and critical revisions. TT was responsible for the study design, drafting the manuscript, and critical revisions. YK and AT participated in the study design, coordination, and critical revisions. AF and TI participated in its design and coordination. All authors were involved in the critical revision of the manuscript and approved the final version of the manuscript.

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Availability of data and materials

Data share is not applicable to this manuscript.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

Author details

[1]Division of Blood Purification Center, Kamifukuoka General Hospital, 931 Fukuoka, Fujimino, Saitama 356-0011, Japan. [2]Department of Living and Welfare, The Open University of Japan, Chiba, Japan. [3]Hemodialysis Center, Akita Urologic Clinic, Akita, Japan. [4]Department of Blood Purification, National Defence Medical College Hospital, Saitama, Japan.

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