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Comparison of difficulty with activities of daily living in elderly adults undergoing hemodialysis and community-dwelling individuals: a cross-sectional study

Toshiki Kutsuna[1,2*], Yusuke Isobe[2], Takaaki Watanabe[2], Yusuke Matsunaga[3,4], Satomi Kusaka[1], Yasuaki Kusumoto[1], Junko Tsuchiya[1], Masaru Umeda[1], Hiroyuki Watanabe[5], Shinobu Shimizu[5], Atsushi Yoshida[6] and Atsuhiko Matsunaga[2,5]

Abstract

Background: Elderly adults undergoing hemodialysis (HD) have multiple comorbidities, physical frailty, and functional dependence with activities of daily living (ADL). ADL difficulty is an early predictor of ADL dependency in community-dwelling elderly adults. However, the characteristics of ADL difficulty in patients undergoing HD have not yet been reported. The present study aimed to examine the current status and characteristics of physical function and ADL difficulty in ambulatory elderly patients undergoing HD.

Methods: In all, 136 elderly outpatients undergoing HD and 40 community-dwelling controls participated in the present study. The characteristics, physical function (SARC-F score, grip strength, five-times sit-to-stand test time, usual gait speed, maximum gait speed, and short physical performance battery score), and scores from the ADL difficulty questionnaires [difficulty related to upper limb (U/L) and lower limb (L/L) functions] were compared between the HD and control groups. Multiple regression analysis was performed to examine whether the characteristics of physical function were able to discriminate ADL difficulty in the HD group.

Results: The HD group had a significantly greater SARC-F score, lower grip strength, longer five-times sit-to-stand test time, slower usual gait speed, slower maximum gait speed, lower short physical performance battery score, and lower U/L and L/L ADL difficulty scores compared to the control group (all $P < 0.001$). The distribution of U/L and L/L ADL difficulty scores showed a wider variation in the HD group than in the control group. The U/L ADL difficulty score was independently associated with the SARC-F score ($\beta = -0.52$, $P < 0.001$) and grip strength ($\beta = 0.21$, $P = 0.02$). The L/L ADL difficulty score was independently associated with the SARC-F score ($\beta = -0.56$, $P < 0.001$) and usual gait speed ($\beta = 0.35$, $P < 0.001$).

Conclusions: The elderly HD group had a poorer physical function and experienced stronger ADL difficulty than the control group. There was an association between ADL difficulty and sarcopenia or poor physical function among patients undergoing HD. These findings provide useful data for effective clinical management to prevent decline of ADL in ambulatory elderly patients undergoing HD.

Keywords: Activities of daily living, Difficulty, Elderly, Hemodialysis, Muscle strength, Physical function, Questionnaire, Sarcopenia, Walking ability

* Correspondence: t.kutsuna.1981@gmail.com
[1]Department of Physical Therapy, School of Health Sciences, Tokyo University of Technology, 5-23-22 Nishikamata, Ota-ku, Tokyo 144-8535, Japan
[2]Department of Rehabilitation Sciences, Kitasato University Graduate School of Medical Sciences, Sagamihara, Kanagawa, Japan
Full list of author information is available at the end of the article

Background

National and international surveys, such as the Dialysis Outcomes and Practice Pattern Study, showed that the number of elderly adults undergoing hemodialysis (HD) has been increasing all over the world in recent years [1, 2]. Elderly patients undergoing HD are characterized by multiple comorbidities [1, 3], physical frailty [4, 5], and high burden of functional dependence with activities of daily living (ADL) [5, 6]. In a prospective cohort study, the appearance of physical frailty, such as slower gait speed, was one of the factors for ADL dependency [7]. Moreover, it was shown that ADL dependency deteriorated the quality of life and increased the risk of mortality [8, 9]. Therefore, there is a need for measures to predict and detect ADL dependency in advance for elderly patients undergoing HD.

The guidelines of European Renal Best Practice, a clinical practice guideline on the management of older patients with chronic kidney disease, recommended measuring the ADL level regularly similar to that for physical function in elderly patients [10]. Moreover, the Japanese Society of Renal Rehabilitation has encouraged the evaluation of ADL level along with physical function and quality of life as outcome measures of renal rehabilitation in the clinical practice guideline for renal rehabilitation [11]. In a report on community-dwelling elderly adults, mobility difficulties were shown as an early predictor of ADL dependency [12]. Although the evaluation of ADL difficulty such as mobility difficulty is considered important for the prediction and early detection of ADL dependency, almost all reports concerning ADL level in patients undergoing HD have focused on ADL dependency [5–9, 13, 14]. A few studies reported that most of these patients who had no ADL dependency experienced difficulty when performing some ADL [15, 16]. However, the results were limited because of the lack of control participants. We believe that evaluating the current status and characteristics of ADL difficulty in elderly patients undergoing HD is essential for the improvement of the patient's treatment environment and life.

The present study aimed to examine the current status and characteristics of ADL difficulty in ambulatory elderly patients undergoing HD by comparing the physical functions and ADL difficulties between elderly adults undergoing HD and community-dwelling individuals as control.

Methods

Participants and study design

Japanese elderly adults who were 65 years or older were included in the present study. Outpatients undergoing HD at one dialysis unit were recruited as the study participants. All patients were undergoing maintenance HD therapy thrice a week and were clinically stable. Patients were excluded if they were within 3 months of dialysis initiation, were hospitalized within 3 months prior to the study, and had severe arthralgia or myalgia, severe motor paralysis, and severe dementia. We posted information regarding the recruitment of study participants in the community bulletin and targeted elderly adults who volunteered for the study as the control group. The control participants were able to come to the venue for assessment independently and were excluded if they had the following medical history: orthopedic diseases, cardiovascular diseases, respiratory diseases, central nervous system diseases, or diabetes mellitus.

This was a cross-sectional study, and all data were collected from May 2017 to February 2019. The purpose of the study was explained to all the participants and written informed consent was obtained. The present study was performed according to the guidelines of the Declaration of Helsinki and approved by the research ethics committees of Kitasato University (approval number: 2016-014) and Tokyo University of Technology (approval number: E18HS-018).

Characteristics

Patient characteristics including age, sex, height, body weight, body mass index, and living alone status (yes or no) were collected for both the HD and control groups. The duration of HD, primary kidney disease, comorbid condition, serum albumin levels, and blood hemoglobin levels were investigated from the clinical records only in the HD group. The comorbid condition was evaluated using a comorbidity index score developed for dialysis patients consisting of primary kidney disease and 11 comorbidities [17].

Physical function

We evaluated the subjects using SARC-F, which was developed and validated as a screening tool for sarcopenia. The SARC-F is a self-administered questionnaire and has five items, including strength, assistance in walking, rise from a chair, climb stairs, and falls. The scale scores ranged from 0 to 2 points for each item [18]. The total score ranged from 0 to 10 points (i.e., 0 = best, 10 = worst), and score of ≥ 4 points indicate the risk of sarcopenia [19].

Grip strength was measured as an indicator of muscle strength of the upper limb using a digital dynamometer (Grip D; Takei Scientific Instruments, Niigata, Japan). Participants were asked to grip a dynamometer as tightly as possible for 3 s with the elbow joint fixed at 90 ° in the sitting position [20]. Grip strength was measured twice on each hand and the highest value (kg) was used in the analysis. A grip strength of < 26 kg (for men) and < 18 kg (for women) are considered the cut-off values of sarcopenia diagnosis [21].

The five-times sit-to-stand test time was measured as an indicator of muscle strength of the lower limb using a stopwatch and a chair with a seat of 40 cm. Participants were asked to stand up five times as quickly as possible with their arms across in front of the chest [22]. The time from the first sitting position to the fifth standing position was measured twice, and the fastest value (s) was used in the analysis.

The usual gait speed and maximum gait speed were measured as indicators of walking ability using a stopwatch. Participants were asked to walk down a 10-m walkway with an acceleration area at their self-chosen usual speed, and maximum speed without running [23]. Each test was measured twice and the faster values (m/s) for each gait speed were used in the analysis. The usual gait speed of < 0.8 m/s was used as the cut-off value of sarcopenia diagnosis [21], and ≤ 1.0 m/s indicated the risk of hospitalization and decline in health status [24]. The maximum gait speed of ≤ 1.50 m/s (for men) and ≤ 1.35 m/s (for women) are suggestive of the risk of cardiovascular mortality [25].

The short physical performance battery (SPPB) score was measured as an indicator of lower limb function. The SPPB consists of three components, including standing balance, usual gait speed, and five-times sit-to-stand test time. The scale scores ranged from 0 to 4 points for each component [26]. The total score ranged from 0 to 12 points (i.e., 0 = worst, 12 = best), and score of ≤ 9 points indicated the risk of walking disability [27].

ADL difficulty questionnaire

ADL dependency and ADL difficulty are widely used to assess ADL ability. ADL dependency is evaluated as the amount of supervision or assistance required with ADL tasks, while ADL difficulty is evaluated as the perceived difficulty encountered when performing ADL tasks.

ADL difficulty was evaluated with two questionnaires developed for patients undergoing assessment of their perceived difficulty in performing ADL related to upper-limb function (U/L ADL difficulty) and lower-limb function (L/L ADL difficulty) [16, 28]. The participants were asked to rate their perceived difficulty in performing each item on a scale of 1 to 5 (1, not possible; 2, severe difficulty; 3, moderate difficulty; 4, mild difficulty; 5, ease).

U/L ADL difficulty questionnaire consisted of two components, including light work and holding activities, and each component had six and five items, respectively [28]. U/L ADL difficulty score was the sum of all points in 11 items and ranged from 11 to 55 points (i.e., 11 = worst, 55 = best). L/L ADL difficulty questionnaire consisted of three components, including basic ADL, ambulation, and walking up or down stairs, and each component had three, five, and four items, respectively [16]. L/L ADL difficulty score was the sum of all points in 12 items and ranged from 12 to 60 points (i.e., 12 = worst, 60 = best).

Statistical analysis

Sample size calculation was performed using the data of the L/L ADL difficulty score in a previous study [16]. The number of participants in the HD group was set to three times that of the control group because the multivariate analysis was performed using the data of the HD group. We calculated a target sample size of 111 participants in the HD group and 37 participants in the control group to provide 80% power to detect a 5.7-point difference between the HD and control groups, with a two-sided alpha level of 0.05 using a standard deviation of 10.6.

The characteristics, physical function, and ADL difficulty were compared between the HD and control groups using the Student t test, Mann-Whitney U test, and chi-square test. The median score of each item of ADL difficulty and score distribution of each item were compared between the HD and control groups using the Mann-Whitney U test and chi-square test. To compare the score distribution of the ADL difficulty scores, histograms of U/L, and L/L ADL difficulty scores were created at 5-point intervals. Simple and multiple regression analyses were performed to predict U/L and L/L ADL difficulty scores using age, sex, body mass index, living alone status, SARC-F score, HD status (yes or no), grip strength, and usual gait speed. Correlations between physical functions and ADL difficulty scores were analyzed by calculating Spearman's correlation coefficients, and scatter plots were drawn for visualization.

Unless otherwise stated, the data are presented as mean ± standard deviation, number (percentage), or median (interquartile range). Statistical significance was set at a P value of < 0.05. All analyses were performed using JMP® (JMP pro version 14; SAS Institute Inc., Cary, NC, USA).

Results

In all, 136 outpatients undergoing HD and 40 healthy individuals as controls were recruited in the present study. The characteristics, physical function, and ADL difficulty of the study participants are shown in Table 1. In the HD group, the mean age was 73.8 ± 6.7 years, 52.3% of patients were men, the mean body mass index was 21.4 ± 3.4 kg/m^2, and the median duration on HD was 7.5 (3.0–13.5) years. There were no significant differences in characteristics between the HD and control groups. The HD group had a significantly greater SARC-F score, lower grip strength, longer five-times sit-to-stand test time, slower usual gait speed, slower maximum gait speed, lower SPPB score, and lower ADL difficulty scores than the control group (all P < 0.001).

Table 1 Characteristics, physical function, and ADL difficulty of study participants

	Hemodialysis group (n = 136)	Control group (n = 40)	P value
Age (years)	73.8 ± 6.7	75.4 ± 5.8	0.16
65 to 74	78 (57.4)	17 (42.5)	
≥ 75	58 (42.6)	23 (57.5)	
Men	72 (52.3)	20 (50.0)	0.74
Height (m)	1.59 ± 0.09	1.58 ± 0.09	0.30
Body weight (kg)	54.6 ± 11.0	55.5 ± 8.0	0.63
Body mass index (kg/m^2)	21.4 ± 3.4	22.3 ± 2.3	0.11
< 18.5	32 (23.5)	2 (5.0)	
18.5 to 24.9	85 (62.5)	35 (87.5)	
≥ 25.0	19 (14.0)	3 (7.5)	
Duration of hemodialysis (years)	7.5 (3.0, 13.5)	–	–
Primary kidney disease		–	–
Glomerulonephritis	39 (28.7)		
Diabetes	47 (34.6)		
Hypertension	9 (6.6)		
Other	23 (16.9)		
Unknown	18 (13.2)		
Comorbidity index score (points)	7 (5, 9)	–	–
Albumin (g/dL)	3.7 ± 0.3	–	–
Hemoglobin (g/dL)	10.8 ± 0.9	–	–
Living alone	34 (25.0)	5 (12.5)	0.08
SARC-F score (points)	3 (1, 5)	1 (0, 2)	< 0.001
≥ 4	58 (42.6)	1 (2.5)	
Grip strength (kg)	21.6 ± 7.1	26.7 ± 6.6	< 0.001
Male < 26, female < 18	82 (60.3)	7 (17.5)	
Five-times sit-to-stand test time (s) *	11.2 ± 4.6	6.5 ± 2.6	< 0.001
Usual gait speed (m/s)	1.04 ± 0.31	1.59 ± 0.27	< 0.001
< 0.8	29 (21.3)	0 (0.0)	
≤ 1.0	59 (43.4)	0 (0.0)	
Maximum gait speed (m/s)	1.35 ± 0.43	2.00 ± 0.39	< 0.001
Male ≤ 1.50, female ≤ 1.35	75 (55.1)	1 (2.5)	
SPPB score (points)	11 (8, 12)	12 (12, 12)	< 0.001
≤ 9	46 (33.8)	0 (0.0)	
U/L ADL difficulty score (points)	40 (31, 49)	52 (45, 54)	< 0.001
Light work	22 (18, 27)	28 (22, 30)	< 0.001
Holding activities	18 (14, 22)	24 (21, 25)	< 0.001
L/L ADL difficulty score (points)	41 (30, 50)	56 (51, 58)	< 0.001
Basic ADL	11 (9, 13)	14 (12, 15)	< 0.001
Ambulation	18 (12, 24)	25 (21, 25)	< 0.001
Walking up or down stairs	13 (10, 16)	19 (16, 20)	< 0.001

Values are presented as mean ± standard deviation, number (percentage), or median (interquartile range)
*Twelve hemodialysis patients could not complete the five-times sit-to-stand test.
ADL: activities of daily living, *L/L*: lower limb, *SPPB*: Short physical performance battery, *U/L*: upper limb

The scores of the items of the ADL difficulty questionnaire are shown in Table 2. The scores of 10 out of 11 items in the U/L ADL difficulty were significantly lower in the HD group than in the control group (all $P < 0.01$). The scores of all 12 items in the L/L ADL difficulty were significantly lower in the HD group than in the control group (all $P < 0.001$).

The score distribution of the items in the ADL difficulty questionnaire is shown in Fig. 1. For U/L ADL difficulty, the HD group found "Opening a jar that has a tight lid" the most difficult of all 11 items. In the L/L ADL difficulty, the HD group found "Walking up two flights of stairs" as the most difficult of all 12 items. The proportion of patients in the HD group who experienced more difficulty performing each U/L ADL item was significantly higher than that in the control group for all 11 items (all $P < 0.05$). The proportion of patients in the HD group who experienced more difficulty in performing each L/L ADL item was significantly higher than that in the control group for all 12 items (all $P < 0.005$).

The histogram of the ADL difficulty score is shown in Fig. 2. The distribution of U/L and L/L ADL difficulty scores showed a wider variation in the HD group than in the control group. In the U/L ADL, 11.0% and 20.0% scored full points (55 points) in the HD and control groups, respectively. In the L/L ADL, 8.8% and 15.0%

Table 2 Score of the items in the ADL difficulty questionnaire

	Hemodialysis group (n = 136)	Control group (n = 40)	P value
a: U/L ADL difficulty			
Light work			
U-1 Gardening or doing yard work	4 (3, 5)	5 (4, 5)	0.003
U-2 Carrying a heavy object (over 5 kg)	4 (3, 5)	4.5 (3, 5)	0.06
U-3 Making a bed	4 (3, 5)	5 (5, 5)	< 0.001
U-4 Doing heavy household chores	4 (3, 5)	5 (3.25, 5)	0.001
U-5 Changing a lightbulb overhead	4 (3, 5)	5 (4, 5)	< 0.001
U-6 Pushing and opening a heavy door	4 (3, 5)	5 (4, 5)	0.003
Holding activities			
U-7 Unscrewing a PET bottle cap	4 (3, 5)	5 (4, 5)	< 0.001
U-8 Opening a pull-tab can	4 (3, 5)	5 (4, 5)	< 0.001
U-9 Opening a new milk carton	4 (3, 5)	5 (5, 5)	< 0.001
U-10 Using a frying pan with one hand	4 (3, 5)	5 (4, 5)	< 0.001
U-11 Opening a jar that has a tight lid	3 (2, 4)	4 (4, 5)	< 0.001
b: L/L ADL difficulty			
Basic ADL			
L-1 Rising from a chair	4 (3, 5)	5 (5, 5)	< 0.001
L-2 Rising from the floor	3 (3, 4)	4 (4, 5)	< 0.001
L-3 Sitting on the floor	3.5 (3, 5)	5 (4, 5)	< 0.001
Ambulation			
L-4 Walking 100 m	4 (3, 5)	5 (4, 5)	< 0.001
L-5 Walking 300 m	4 (2.25, 5)	5 (4, 5)	< 0.001
L-6 Walking 600 m	3 (2, 5)	5 (4, 5)	< 0.001
L-7 Walking 1 km	3 (1, 4.75)	5 (4, 5)	< 0.001
L-8 Walking 20 m quickly	4 (3, 5)	5 (4, 5)	< 0.001
Walking up or down stairs			
L-9 Walking up one flight of stairs	3 (3, 4)	5 (4, 5)	< 0.001
L-10 Walking up two flights of stairs	3 (2, 4)	4 (4, 5)	< 0.001
L-11 Walking down one flight of stairs	4 (3, 5)	5 (4, 5)	< 0.001
L-12 Walking down two flights of stairs	3 (2, 4)	5 (4, 5)	< 0.001

Values are presented as median (interquartile range)
ADL: activities of daily living, *L/L*: lower limb, *U/L*: upper limb

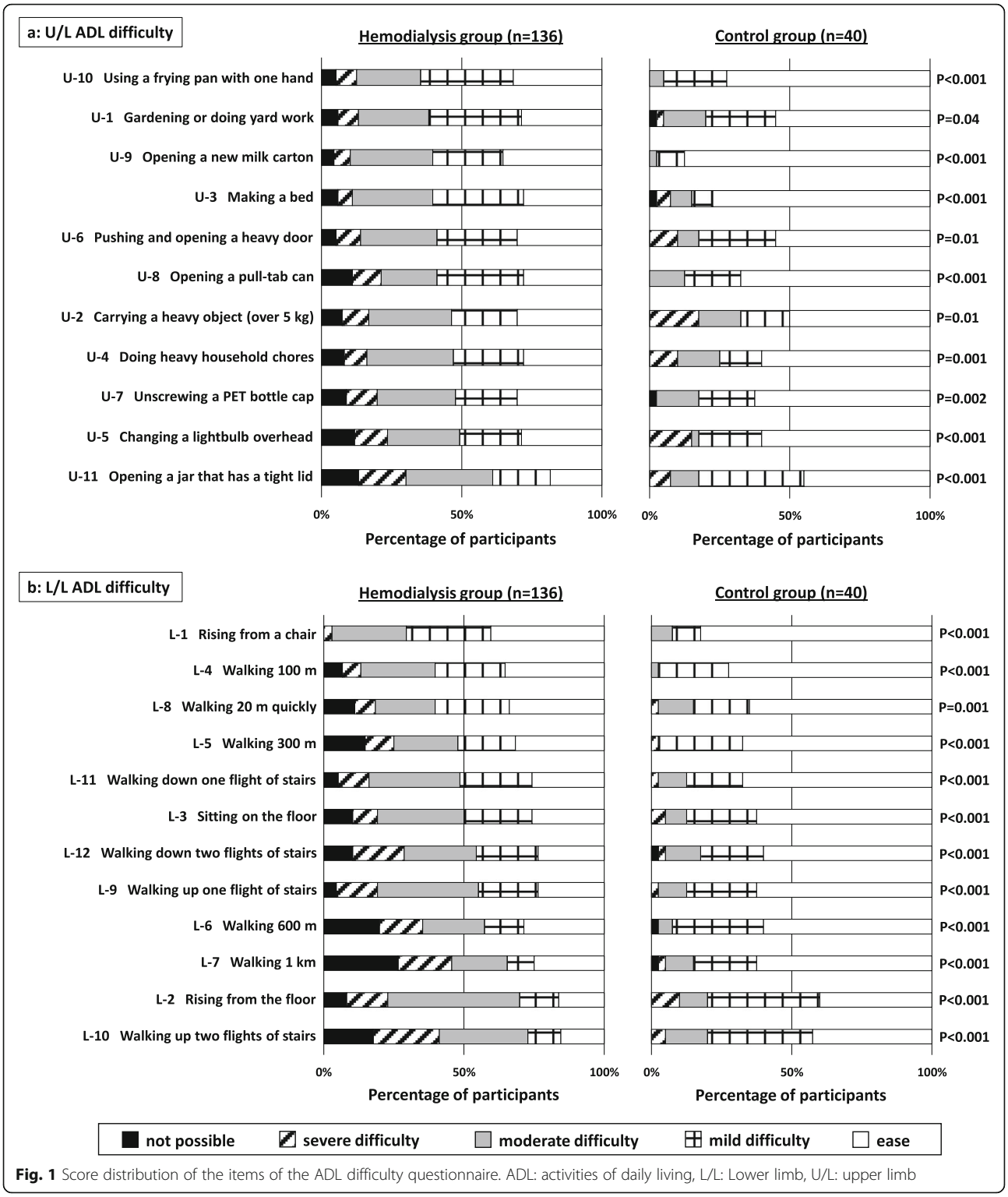

Fig. 1 Score distribution of the items of the ADL difficulty questionnaire. ADL: activities of daily living, L/L: Lower limb, U/L: upper limb

scored full points (60 points) in the HD and control groups, respectively.

The results of simple and multiple regression analyses for the effect on ADL difficulty score are shown in Table 3. The age (β = −0.25, P = 0.001), sex (β = 0.16, P = 0.04), body mass index (β = 0.23, P = 0.002), SARC-F score (β = −0.70, P < 0.001), HD or not (β = −0.34, P < 0.001), grip strength (β = 0.50, P < 0.001), and usual gait speed (β = 0.53, P < 0.001) were significant predictors of the U/L ADL difficulty score in univariate analysis. The SARC-F

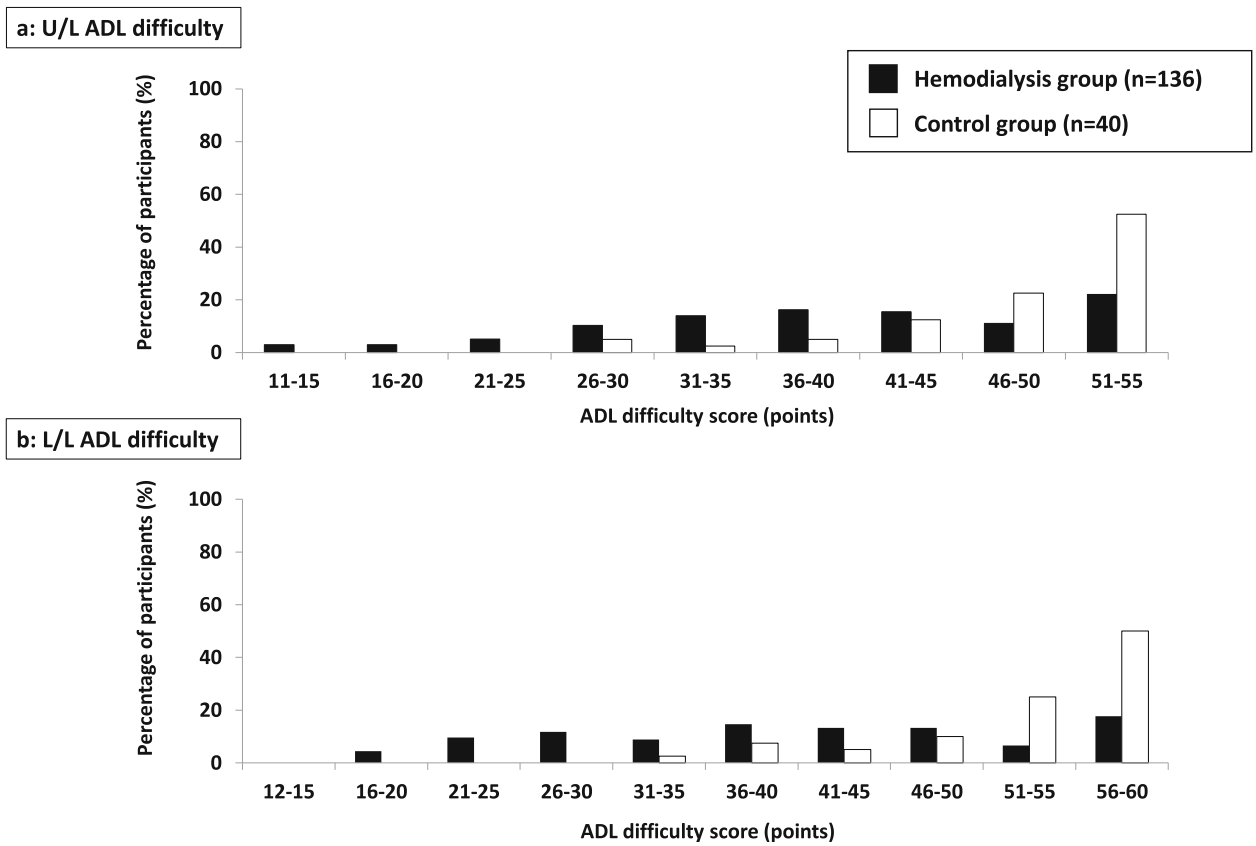

Fig. 2 Histogram of the ADL difficulty score. Closed and open bars indicate the hemodialysis and control groups, respectively. ADL: activities of daily living, L/L: lower limb, U/L: upper limb

score (β = −0.52, $P < 0.001$) and grip strength (β = 0.21, $P = 0.02$) remained significant predictors of the U/L ADL difficulty score after adjusting for age, sex, body mass index, living alone status, HD status, and usual gait speed. Age (β = −0.24, $P = 0.002$), SARC-F score (β = −0.78, $P < 0.001$), HD status (β = −0.43, $P < 0.001$), grip strength (β = 0.36, $P < 0.001$), and usual gait speed (β = 0.72, $P < 0.001$) were significant predictors of L/L ADL difficulty score in the univariate analysis. SARC-F score (β = −0.56, $P < 0.001$) and usual gait speed (β = 0.35, $P < 0.001$) remained significant predictors of the L/L ADL difficulty score after adjusting for age, sex, body mass index, living alone status, HD status, and grip strength.

The scatter plots of physical function and ADL difficulty score in the HD group are shown in Fig. 3. The U/L ADL difficulty score was significantly correlated with the SARC-F score ($r_s = -0.63$, $P < 0.001$) and grip strength ($r_s = 0.45$, $P < 0.001$). The L/L ADL difficulty score was significantly correlated with the SARC-F score ($r_s = -0.75$, $P < 0.001$), five-times sit-to-stand test time ($r_s = -0.52$, $P < 0.001$), usual gait speed ($r_s = 0.66$, $P < 0.001$), maximum gait speed ($r_s = 0.67$, $P < 0.001$), and SPPB score ($r_s = 0.61$, $P < 0.001$).

Discussion

This study investigated the characteristics of ADL difficulty in ambulatory elderly patients undergoing HD by comparing with a control group. The present study showed that physical function, such as muscle strength and walking ability, in these patients was markedly lower than that of control individuals, and most patients had a physical function below the cut-off values for the risk of sarcopenia, disability, or mortality. Moreover, patients experienced more difficulty with various ADL tasks compared to the control individuals, and their ADL difficulty was correlated with the indicators of sarcopenia and deterioration of physical function.

The control group showed a predominance of “ease” and “mild difficulty” in each item of U/L and L/L ADL difficulty, although the difficulty was widely dispersed from “ease” to “not possible” in the HD group. Furthermore, the U/L and L/L ADL difficulty scores were broadly distributed in the HD group, while the scores were inclined towards the higher side in the control group. In a cross-sectional study, it was reported that many patients exhibited ADL difficulty even if they could perform the ADL tasks independently [16]. That

Table 3 Simple and multiple regression analysis of the effect on ADL difficulty score

Variable	Univariate				Multivariate			
	Unstandardized regression coefficient	95% confidence interval	Standardized regression coefficient (β)	*P* value	Unstandardized regression coefficient	95% confidence interval	Standardized regression coefficient (β)	*P* value
a: U/L ADL difficulty								
Intercept					28.16	7.14 to 49.18		
Age (years)	−0.41	−0.66 to −0.17	−0.25	0.001	0.001	−0.19 to 0.19	0.001	0.99
Male	1.71	0.10 to 3.33	0.16	0.04	0.07	−1.48 to 1.61	0.01	0.93
Body mass index (kg/m^2)	0.80	0.29 to 1.30	0.23	0.002	0.34	−0.04 to 0.73	0.10	0.08
Living alone	−1.89	−3.83 to 0.06	0.14	0.06	−0.17	−1.52 to 1.17	−0.01	0.80
SARC-F score (points)	−3.63	−4.18 to −3.08	−0.70	< 0.001	−2.68	−3.41 to −1.95	−0.52	< 0.001
Hemodialysis	−4.38	−6.21 to −2.55	−0.34	< 0.001	0.55	−1.25 to 2.35	0.04	0.55
Grip strength (kg)	0.75	0.56 to 0.95	0.50	< 0.001	0.31	0.06 to 0.56	0.21	0.02
Usual gait speed (m/s)	16.77	13.26 to 20.29	0.53	< 0.001	4.61	−0.24 to 9.46	0.16	0.06
b: L/L ADL difficulty								
Intercept					45.07	24.26 to 65.89		
Age (years)	−0.45	−0.73 to −0.17	−0.24	0.002	−0.04	−0.23 to 0.15	−0.02	0.65
Male	0.74	−1.14 to 2.62	0.06	0.44	0.68	−0.84 to 2.21	0.05	0.38
Body mass index (kg/m^2)	0.26	−0.34 to 0.85	0.07	0.39	−0.03	−0.41 to 0.35	−0.01	0.89
Living alone	−1.57	−3.82 to 0.68	−0.10	0.17	0.70	−0.64 to 2.03	0.05	0.30
SARC-F score (points)	−4.65	−5.21 to −4.10	−0.78	< 0.001	−3.36	−4.08 to −2.63	−0.56	< 0.001
Hemodialysis	−6.39	−8.41 to −4.36	−0.43	< 0.001	−0.17	−1.95 to 1.61	−0.01	0.85
Grip strength (kg)	0.62	0.38 to 0.86	0.36	< 0.001	−0.09	−0.34 to 0.16	−0.05	0.50
Usual gait speed (m/s)	23.93	20.47 to 27.38	0.72	< 0.001	11.61	6.81 to 16.42	0.35	< 0.001

ADL: activities of daily living, *L/L*: lower limb, *U/L* upper limb

is, measuring ADL difficulty may aid the appropriate grading of ADL ability in outpatients undergoing HD. Therefore, it seems important to evaluate ADL difficulty to prevent the progression of decline of ADL dependency in elderly patients undergoing HD.

Previous studies have shown the relationship between the decline in kidney function and ADL dependency or difficulty. A 2-year longitudinal study with community-dwelling older adults reported that chronic kidney disease was a risk factor for decline of basic and instrumental ADL [29]. In a large-scale cross-sectional national survey, the percentage of patients who had ADL dependency and difficulty increased as the chronic kidney disease stage became more severe [30]. Moreover, another observational study showed that the initiation of HD was associated with increased dependency on seven basic ADL tasks in elderly patients with end-stage renal disease [31]. The present study showed that many elderly patients undergoing HD had moderate to severe difficulty in ADL tasks compared with community-dwelling elderly adults. Patients undergoing HD have multiple comorbidities [1, 3], an inactive lifestyle [32], and physical frailty [4, 5], and these factors form a vicious circle. Therefore, we consider that the deterioration of kidney function leading to HD and the initiation of HD adversely affected ADL difficulty similar to ADL dependency.

Multiple regression analysis revealed that sarcopenia and physical function were determinants of ADL difficulty even after adjusting for patient characteristics and presence of HD. According to some reports, the incidence of sarcopenia was high (> 30%) and sarcopenia was reported to be associated with lower grip strength in elderly patients undergoing HD [33, 34]. It is known that patients undergoing HD have poor physical function and physical frailty [35, 36]. These previous reports support the results of the present study, which showed that these elderly patients had more sarcopenia and poor physical functions. Moreover, physical frailty was strongly related to the dependency on four basic ADL tasks in these patients [37]. Therefore, this may explain how the deterioration in physical function affected ADL difficulty which was an early predictor of ADL dependency.

Some limitations of the present study should be acknowledged. First, the result from this study could not address the effects of ADL difficulty on ADL dependency in patients undergoing HD because this study had a cross-sectional design. Physical frailty progresses

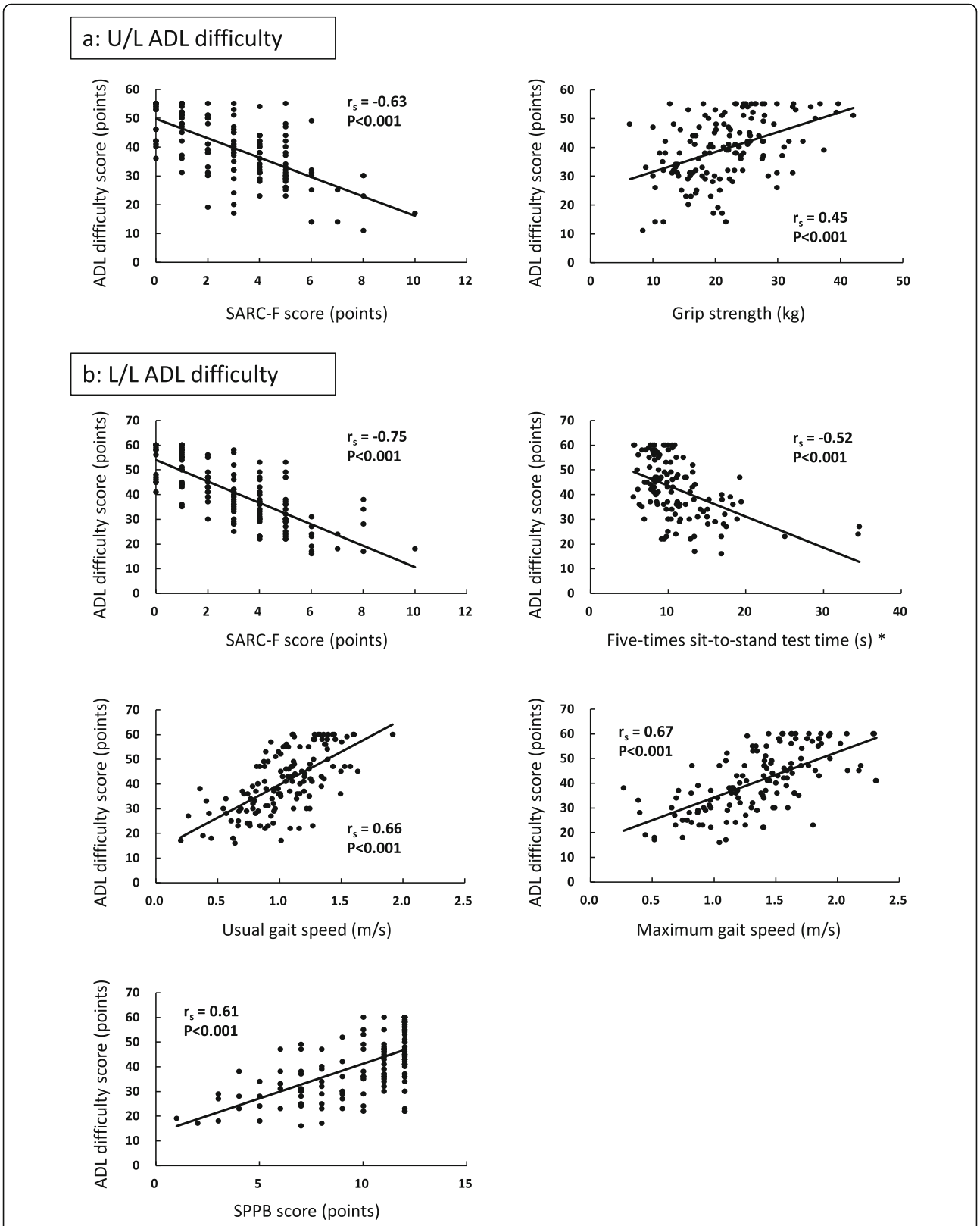

Fig. 3 Scatter plots of physical function and ADL difficulty score in the hemodialysis group. *Twelve hemodialysis patients could not complete the five-times sit-to-stand test. ADL: activities of daily living, L/L: lower limb, SPPB: Short physical performance battery, U/L: upper limb

gradually and results in ADL difficulty and ADL dependency in elderly adults [38, 39]. Therefore, further research is needed to observe long-term changes in ADL difficulty and to examine the relationship with ADL dependency in these elderly patients. Second, the study participants were patients undergoing HD who did not have arthralgia, myalgia, or motor paralysis. Elderly patients undergoing HD tend to have multiple comorbidities [1, 3]. In such patients with severe comorbidities, the characteristics of physical function and ADL difficulty may be different from the results of this study.

Conclusions

Ambulatory elderly patients undergoing HD had poorer physical function and stronger ADL difficulty than control community-dwelling elderly adults. There was an association between the ADL difficulty and sarcopenia or poor physical function among these patients. These findings among patients undergoing HD are useful, given the well-known association between the poor physical function and ADL dependency in the general elderly population.

Abbreviations

ADL: Activities of daily living; HD: Hemodialysis; L/L: Lower limb; SARC-F: Strength, assistance in walking, rise from a chair, climb stairs, and falls; SPPB: Short physical performance battery; U/L: Upper limb

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Authors' contributions

TK, YI, TW, MU, HW, SS, AY, and AM made substantial contributions to the conception and design of the work. TK, YI, TW, YM, SK, YK, and JT performed measurements of the physical function and ADL difficulty. TK and YI prepared and analyzed the dataset. TK and AM interpreted the data and drafted the work. All authors read and approved the final version of the manuscript.

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Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

The present study was performed according to the ethical standards Declaration of Helsinki and approved by the ethics committees of Kitasato University (approval number: 2016-014) and Tokyo University of Technology (approval number: E18HS-018). Informed consent was obtained from all individual participants included in the present study.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

Author details

[1]Department of Physical Therapy, School of Health Sciences, Tokyo University of Technology, 5-23-22 Nishikamata, Ota-ku, Tokyo 144-8535, Japan. [2]Department of Rehabilitation Sciences, Kitasato University Graduate School of Medical Sciences, Sagamihara, Kanagawa, Japan. [3]Department of Clinical Psychology, Tsurukawa Sanatorium Hospital, Tokyo, Japan. [4]Department of Health Science, School of Allied Health Sciences, Kitasato University, Sagamihara, Japan. [5]Department of Rehabilitation, School of Allied Health Sciences, Kitasato University, Sagamihara, Japan. [6]Department of Hemodialysis Center, Sagami Circulatory Organ Clinic, Sagamihara, Japan.

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