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Determinants of difficulty in activities of daily living in ambulatory patients undergoing hemodialysis

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Abstract

Background: Patients undergoing hemodialysis (HD) have difficulty performing activities of daily living (ADL) compared to healthy people. ADL difficulty is an early predictor of loss of independence and mortality in older community-living people. However, determinants of ADL difficulty in HD patients have not been clarified. This study aimed to identify factors associated with ADL difficulty in ambulatory HD patients.

Methods: Subjects were 216 Japanese outpatients (130 men, 86 women; mean age, 67 years) undergoing maintenance HD three times a week. Clinical characteristics, depressive symptoms, motor function (leg strength, balance, and walking speed), and ADL difficulty related to lower-limb function such as mobility issues were compared across three difficulty levels (higher, middle, and lower) as classified according to the percentages of patients with perceived difficulty. Multivariate logistic regression analysis was performed to examine whether clinical characteristics, depressive symptoms, and motor function could discriminate ADL difficulty at each level. Receiver operating characteristic curve analysis was performed to determine cut-off values of motor function for predicting ADL difficulty at each level.

Results: ADL difficulty was independently associated with age (odds ratio (OR) = 1.05, 95% confidence interval (CI) 1.00–1.10; $P = 0.039$), presence of depressive symptoms (OR = 4.24, 95%CI 1.13–15.95; $P = 0.033$), and usual walking speed (OR = 0.94, 95%CI 0.90–0.97; $P < 0.001$) for higher level difficulty; age (OR = 1.06, 95%CI 1.02–1.10; $P = 0.006$), maximum leg strength (OR = 0.97, 95%CI 0.94–1.00; $P = 0.043$), and usual walking speed (OR = 0.96, 95%CI 0.93–0.98; $P = 0.001$) for middle level difficulty; and age (OR = 1.06, 95%CI 1.02–1.10; $P = 0.006$) and usual walking speed (OR = 0.93, 95%CI 0.90–0.6; $P < 0.001$) for lower level difficulty. Cut-off values of usual walking speed for predicting ADL difficulty for higher, middle, and lower level difficulty were 83.7, 75.5, and 75.1 m/min, respectively.

Conclusions: A slow walking speed and old age were significantly and independently associated with ADL difficulty in ambulatory HD patients. Presence of depressive symptoms was significantly and independently associated with ADL difficulty at the higher level of difficulty in ambulatory HD patients. These findings provide useful data for planning effective therapeutic regimens to prevent ADL difficulty in ambulatory HD patients.

Keywords: Activities of daily living (ADL) difficulty, Depressive symptom, Walking speed, Hemodialysis patient

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Background

Evaluation of physical functioning in maintenance hemodialysis (HD) patients is recommended by the Kidney Disease Outcomes Quality Initiative clinical practice guidelines [1] and European Renal Best Practice guidelines [2], as decreased physical functioning leads to a reduced quality of daily life and higher risk of mortality in this patient population [1–4]. These guidelines recommend assessment of physical functioning using both self-reported and open-field measures of physical performance [2, 5, 6]. In particular, self-reported measures of physical functioning have the advantage of being simple and easy to use [2].

In Japan, more than half of HD patients reportedly have the ability to perform basic activities of daily living (ADL) and instrumental ADL tasks without assistance [7]. However, even HD patients who can perform ADL tasks independently show high rates of ADL difficulty, i.e., difficulty carrying out routine self-care activities. Kutner et al. [8] reported that HD patients are more likely to have ADL difficulty compared to age-matched controls. Moreover, HD patients have been reported to show poor physical functioning (e.g., leg strength, standing balance, and walking ability), with high rates of depressive symptoms [9–13]. Recent studies have shown that poor standing balance, slow walking speed, presence of depression, and chronic kidney disease predict ADL difficulty in older community-living people [14–17]. Moreover, ADL difficulty has been shown to be an early predictor of loss of independence and mortality in older community-living people [18]. However, few studies have examined factors associated with ADL difficulty in HD patients. Therefore, this study aimed to identify factors associated with ADL difficulty in clinically stable ambulatory HD patients.

Methods

Study population

The study protocol was approved by the Ethics Committee of Kitasato University. Informed consent was obtained from each patient after providing a detailed explanation of the study protocol. From July 2007 to October 2016, clinically stable outpatients at the Sagami Circulatory Organ Clinic Hemodialysis Center were assessed for eligibility for inclusion in this cross-sectional study. Patients were undergoing maintenance HD therapy three times a week according to the Japanese Society for Dialysis Therapy guidelines. Patients were excluded if they fulfilled the following criteria: hospitalization ≤ 3 months prior to study enrollment; presence of uncontrolled cardiac arrhythmias, severe disdialysis syndrome (hypotension, nausea, and muscle spasm during hemodialysis), peripheral artery disease with apparent intermittent claudication or critical limb ischemia, chronic heart failure (New York Heart Association classes III to IV), or uncontrolled hypertension (blood pressure at rest > 180/110 mmHg); need for walking assistance; and presence of any other conditions that limited walking (e.g., dementia, low vision or blindness, paralysis due to stroke, and leg amputation).

Clinical characteristics

Information regarding age, sex, HD duration, body mass index (BMI), primary end-stage renal disease, and laboratory values (blood hemoglobin and serum albumin) was obtained from clinical records. BMI was calculated by dividing weight in kilograms by the square of height in meters. Blood hemoglobin and serum albumin concentrations were measured immediately before each hemodialysis session.

Presence of diabetes mellitus, cerebrovascular disease (stroke), and cardiac disease (angina pectoris, myocardial infarction, percutaneous coronary intervention, or coronary artery bypass grafting) was assessed based on clinical records. Moreover, to quantify comorbid illnesses, we used a comorbidity index developed for dialysis patients, which comprised the following primary causes of kidney disease: atherosclerotic heart disease, congestive heart failure, cerebrovascular accident/transient ischemic attack, peripheral vascular disease, dysrhythmia, and other cardiac diseases; chronic obstructive pulmonary disease; gastrointestinal bleeding; liver disease; cancer; and diabetes [19].

Depressive symptoms

A short, 10-item version of the Center for Epidemiological Studies Depression Screening Index (CES-D) was used to assess depressive symptoms in the last 7 days [13, 20, 21]. Each response item is rated on a scale ranging from 0 to 3. Total CES-D score was calculated as the sum of all item scores and ranged from 0 to 30. Higher scores indicated greater depressive symptoms, and the presence of depressive symptoms was defined as a score of ≥ 10 [21].

Motor function

Assessment of motor function included measurements of leg strength, standing balance, and walking ability. Leg strength was evaluated using a handheld dynamometer (μtas F-1; Anima, Tokyo, Japan). Patients were asked to sit on a bench with their hip and knee flexed at an angle of 90°, and then, the maximum voluntary isometric knee extensor strength was measured three times. Maximum leg strength was expressed as a percentage of body weight, i.e., the average of right and left maximum isometric leg strength divided by weight [22, 23].

Standing balance was evaluated by measuring one-leg standing time. The duration that patients could stand on one leg with their eyes open, while holding their hands at their waist without any aid or falling, was measured using a stopwatch [24]. The measurement was performed for up

to 60 s and stopped if patients hopped, stepped, put the raised foot down on the other foot or on the floor, or released their hands from the waist. Patients underwent a second trial if they were unable to stand on one leg for 60 s in the first trial [25]. The maximum time of the two measurements was used for analysis.

Walking ability was evaluated by measuring usual walking speed along a 10-m walkway. Usual walking speed was defined as distance (10-m) divided by time (in minutes) from self-selected walking speed [22]. Usual walking speed was measured once and was expressed in meter per minutes.

ADL dependency

ADL dependency was assessed by the Functional Independence Measure (FIM). The FIM is widely used to measure patient functional status for performing ADL. In the USA, the FIM has been used as a primary outcome measure and, approximately, 60% of US hospitals used the FIM in 2002 [26]. The FIM comprises 13 motor items and five cognitive items, which are rated on a 7-point scale (1, complete assistance, to 7, complete independence) [27, 28]. In this study, only five motor items (transfer to bed, chair, or wheelchair; transfer to toilet; transfer to tub or shower; walking or wheelchair propulsion; and stair climbing) related to lower-limb function were used, with a total score of 7 to 35 points. Lower scores indicated greater ADL dependency.

ADL difficulty

ADL difficulty was assessed with a questionnaire developed for patients undergoing HD therapy to assess their perceived difficulty in performing ADL related to lower-limb function such as mobility. This questionnaire on perceived mobility difficulty for HD patients comprises 12 items divided into the following three categories, which were obtained by a factor analysis: "basic ADL," "ambulation," and "walking up or down stairs" [29, 30]. The reliability and validity of the questionnaire have been assessed in Japanese HD patients [29, 30]. The English version of this questionnaire was created through a process of repeated translation from Japanese to English by a bilingual physiotherapist (A.M.) and then back-translated by a bilingual translator.

Additional file 1: Table S1 shows the 12 items of the questionnaire. Patients were asked to rate their perceived difficulty in performing these items on a scale of 1 to 5 (1, not possible; 2, severe difficulty; 3, moderate difficulty; 4, mild difficulty; and 5, ease). ADL difficulty score was defined as the sum of all points and ranged from 12 to 60 points. Lower scores indicated greater ADL difficulty.

Statistical analysis

To compare score distribution, histograms of ADL dependency and difficulty scores from all patients were created at 5-point intervals. According to a method described previously [29], the 12 items of the ADL difficulty questionnaire were classified into three difficulty levels (higher, middle, and lower). Then, patients with a perceived difficulty score ≤ 3 for at least one item in each level were allocated into the difficulty group, and other patients (perceived difficulty score ≥ 4 for all items) were allocated into the non-difficulty group. Differences in clinical characteristics (age, sex, BMI, HD duration, primary cause of end-stage renal disease, hemoglobin, serum albumin, and comorbid conditions), depressive symptoms, motor function (maximum leg strength, one-leg standing time, and usual walking speed), and ADL dependency and difficulty scores between the two groups were assessed for significance using the non-paired t test and χ^2 test. Univariate and multivariate logistic regression analyses were performed to assess whether clinical characteristics and motor function could discriminate the presence of ADL difficulty for each level. Independent variables used for multivariate logistic regression analysis were age, sex, blood hemoglobin concentration, serum albumin concentration, comorbidity index, depression symptoms, maximum leg strength, one-leg standing time, and usual walking speed for each level. Receiver operating characteristic (ROC) curve analysis was performed to determine cut-off values of motor function for predicting ADL difficulty at each level. Cut-off values were determined according the maximum Youden index [31].

All analyses were performed using the Statistical Package for Social Sciences (IBM SPSS Statistics 24.0 for Windows; IBM Corp., Armonk, NY, USA). $P < 0.05$ was considered statistically significant.

Results

Patient characteristics, motor function, ADL dependency, and ADL difficulty

As shown in Fig. 1, 199 of 564 Japanese HD outpatients who were assessed for eligibility fell under the exclusion criteria, and 149 declined to participate. Consequently, 216 patients (130 men, 86 women) were included in this study.

Additional file 2: Table S2 shows the clinical characteristics, motor function, ADL dependency, and ADL difficulty of all 216 patients (mean age, 67.4 years; age range, 36–90 years). The most common underlying kidney disease was glomerulonephritis (35.2%), followed by diabetic nephropathy (31.9%). Mean ADL dependency and difficulty scores were 34.3 ± 0.9 and 43.6 ± 10.6 points, respectively.

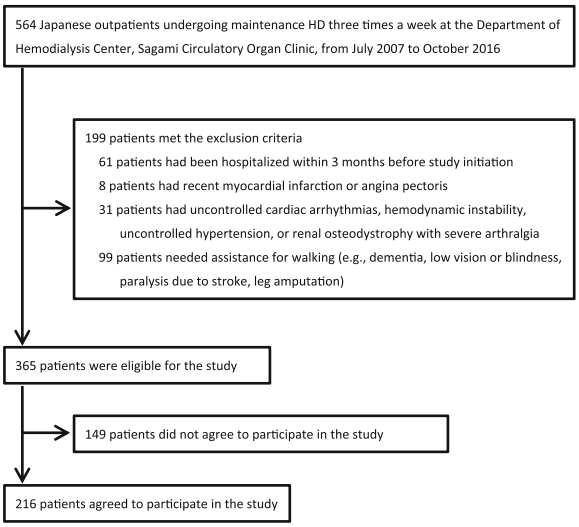

Fig. 1 Flow diagram of participant selection and exclusion

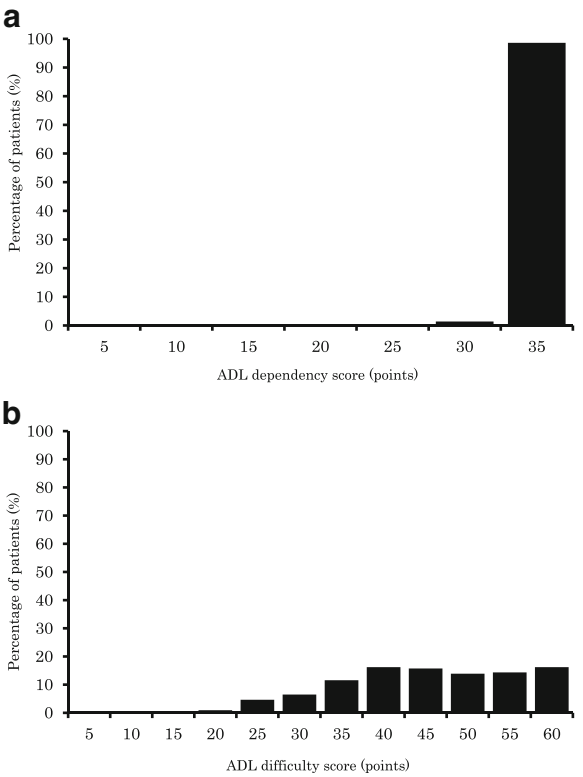

Fig. 2 Histogram of ADL dependency and ADL difficulty scores. **a** ADL dependency was assessed by the FIM. **b** ADL difficulty was assessed by the questionnaire on perceived mobility difficulty. ADL, activities of daily living; FIM, functional independence measure

Figure 2a shows the distribution of ADL dependency scores. Fifty-two percent (113 persons) scored full points. Figure 2b displays the distribution of ADL difficulty scores, showing wide variation. Four percent (nine persons) scored full points.

As shown in Fig. 3, patients found "walking up two flights of stairs" the most difficult of all 12 items, followed by "walking 1 km," "walking 600 m," "rising from the floor," "walking down two flights of stairs," "walking 300 m," "walking up one flight of stairs," "sitting down on the floor," "walking 20 m quickly," "walking down one flight of stairs," "walking 100 m," and "rising from a chair." Furthermore, based on the percentages of patients with a perceived difficulty score ≤ 3, "walking up two flights of stairs," "walking 1 km," "walking 600 m," and "rising from the floor" were classified as ADL items with higher level difficulty; "walking down two flights of stairs," "walking 300 m," "walking up one flight of stairs," and "sitting down on the floor" were classified as ADL items with middle level difficulty; and "walking 20 m quickly," "walking down one flight of stairs," "walking 100 m," and "rising from a chair" were classified as ADL items with lower level difficulty.

Differences in clinical characteristics, motor function, depressive symptoms, ADL dependency score, and ADL difficulty score between the difficulty and non-difficulty groups for each difficulty level are shown in Additional file 2: Table S2. For higher level difficulty, significant differences were observed between the two groups in age ($P < 0.001$), presence of depressive symptoms ($P = 0.002$), maximum leg strength ($P < 0.001$), one-leg standing time ($P < 0.001$), and usual walking speed ($P < 0.001$). For middle level difficulty, significant differences were observed in age ($P < 0.001$), presence of depressive symptoms ($P = 0.001$), maximum leg strength ($P < 0.001$), one-leg standing time ($P < 0.001$), and usual walking speed ($P < 0.001$). For lower level difficulty, significant differences were observed in age ($P < 0.001$), maximum leg strength ($P < 0.001$), one-leg standing time ($P < 0.001$), and usual walking speed ($P < 0.001$).

Univariate and multivariate logistic regression analyses on ADL difficulty

The results of univariate and multivariate logistic regression analyses on ADL difficulty are shown in Additional file 3: Table S3. As shown in Additional file 3: Table S3, the results of multivariate logistic regression analysis on ADL difficulty revealed that presence of depressive symptoms (odds ratio (OR) = 4.03, 95% confidence interval (CI) 1.12–14.50; $P = 0.033$) and usual walking speed (OR = 0.94, 95%CI 0.90–0.97; $P < 0.001$), after adjusting for age and sex (model 1), and presence of depressive symptoms (OR = 4.24, 95%CI 1.13–15.95; $P = 0.033$) and usual walking speed (OR = 0.94, 95%CI 0.90–0.97; $P < 0.001$), after adjusting for model 1 plus hemoglobin, serum albumin, and comorbidity index, were significantly associated with ADL difficulty at the higher level of difficulty. At the middle level of difficulty, maximum leg strength (OR = 0.97, 95%CI 0.94–1.00; $P = 0.043$) and usual walking speed (OR = 0.96, 95%CI

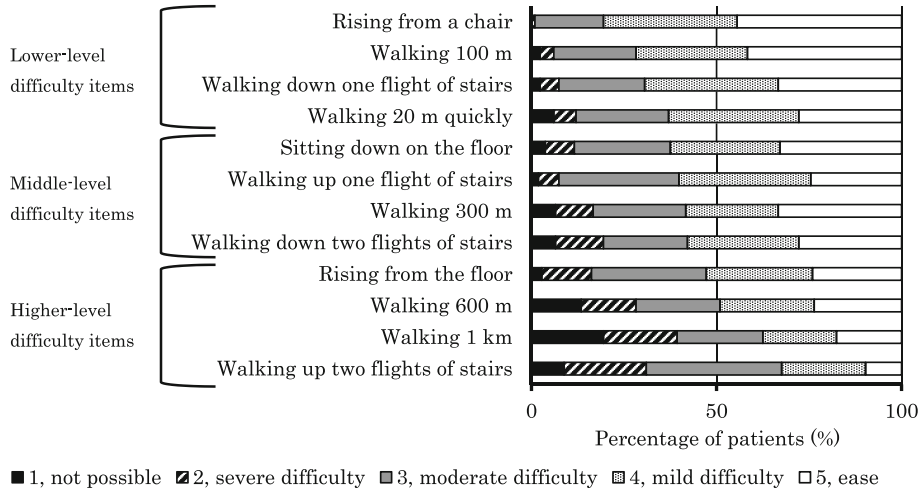

Fig. 3 Difficulty levels and distribution of 12 items of the questionnaire on perceived mobility difficulty

0.93–0.98; $P = 0.001$), in model 1, and maximum leg strength (OR = 0.97, 95%CI 0.94–1.00; $P = 0.043$) and usual walking speed (OR = 0.96, 95%CI 0.93–0.98; $P = 0.001$), in model 2, were significantly associated with ADL difficulty. At the lower level of difficulty, usual walking speed (OR = 0.93, 95%CI 0.90–0.96; $P < 0.001$), in model 1, and usual walking speed (OR = 0.93, 95%CI 0.90–0.96; P < 0.001), in model 2, were significantly associated with ADL difficulty.

ROC curves and cut-off values of usual walking speed for predicting ADL difficulty

Since usual walking speed was significantly associated with ADL difficulty across all three levels, ROC curves were generated for usual walking speed. Figures 4, 5, and 6 show the ROC curves of usual walking speed for predicting ADL difficulty at each level. The areas under the ROC curves of usual walking speed for predicting ADL difficulty at higher, middle, and lower levels were 0.82 ($P < 0.001$), 0.78 ($P < 0.001$), and 0.82 ($P < 0.001$), respectively. Cut-off values of usual walking speed for predicting ADL difficulty at higher, middle, and lower levels were 83.7, 75.5, and 75.1 m/min, respectively.

Discussion

In the present cross-sectional study, ADL difficulty scores varied widely among HD patients, whereas more than half of HD patients scored full points for ADL dependency. We classified the 12 items of the ADL difficulty questionnaire into three difficulty levels (higher, middle, and lower) based on the percentages of patients with a perceived difficulty score ≤ 3 in order to identify determinants of ADL difficulty. Multivariate logistic regression analysis revealed that common factors independently associated with ADL difficulty were old age and low usual walking speed for all difficulty levels, presence of depressive symptoms for higher level difficulty, and decreased maximum leg strength for middle level difficulty. Cut-off values of usual walking speed for predicting the presence of ADL difficulty for higher, middle, and lower level difficulty were 83.7, 75.5, and 75.1 m/min, respectively.

HD patients reportedly have a significantly higher ADL difficulty score compared to healthy controls [8]. Patients hospitalized due to heart failure have also been shown to have difficulty in walking (29.0%) and climbing stairs (45.9%) [32]. In the present study, 61 (28.2%) and 86 (39.8%) patients reported difficulty in walking 100 m

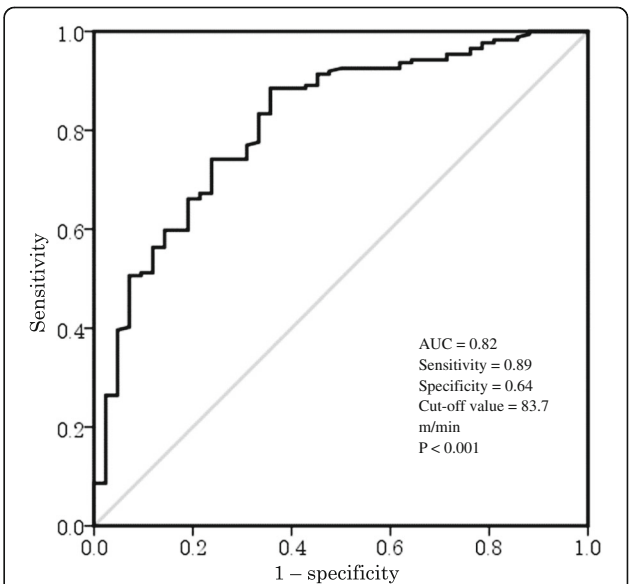

Fig. 4 ROC curve of usual walking speed for predicting ADL difficulty at higher level of difficulty. *ROC* receiver operating characteristic, *ADL* activities of daily living, *AUC* area under the curve

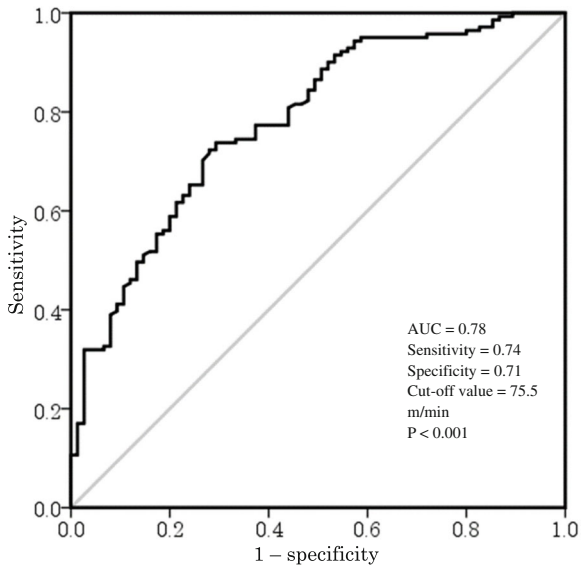

Fig. 5 ROC curve of usual walking speed for predicting ADL difficulty at middle level of difficulty. *ROC* receiver operating characteristic, *ADL* activities of daily living, *AUC* area under the curve

and walking up one flight of stairs, respectively, suggesting that prevalence rates of reported difficulty are similar between HD patients and hospitalized patients with heart failure.

In this study, usual walking speed was significantly associated with ADL difficulty at all three levels after adjustment for confounders. In a previous cross-sectional study, walking speed was associated with ADL difficulty in community-dwelling adults aged 65 and older [33]. Moreover, an 18-month prospective study reported that walking speed can predict the onset of ADL difficulty in older women aged 70–80 years [14]. Our findings are in line with these reports.

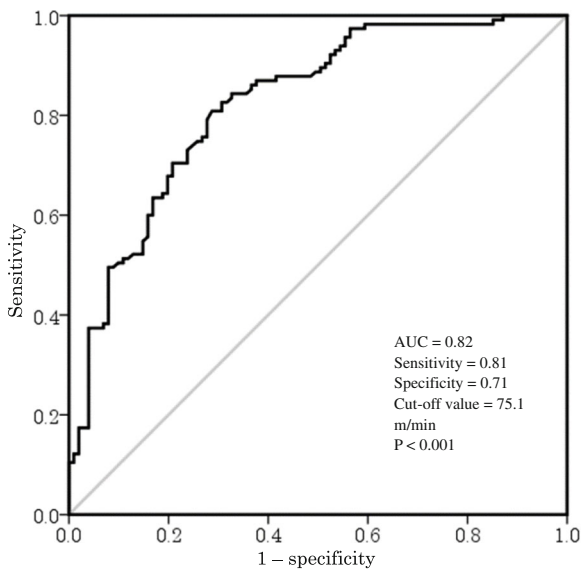

Fig. 6 ROC curve of usual walking speed for predicting ADL difficulty at lower level of difficulty. *ROC* receiver operating characteristic, *ADL* activities of daily living, *AUC* area under the curve

The presence of depressive symptoms was significantly associated with ADL difficulty at the higher level of difficulty. Depression has been attributed to disabilities in basic ADL (e.g., inability to bathe, eat, dress, transfer from a bed to a chair, use the toilet, or walk across a small room), mobility (e.g., unable to walk a short distance without help, or walking up and down stairs without help), and limited social activity (e.g., social withdrawal or social isolation) in older community-dwelling adults [34, 35]. Generally, collective social activity is defined as spending time and participating in activities together with other people, such as visiting cultural events, traveling, exercise, or participating in organizational activities. Therefore, social activity requires higher levels of mobility, e.g., more than that required to walk around at home. Moreover, the rate of onset of mobility disabilities after 6 years has been reported to be higher (67.1%) compared to that of basic ADL disabilities (36.1%) in patients with depression at baseline [34]. In our study, only a few participants had basic ADL disabilities. Therefore, depressive symptoms likely had a greater impact on high difficulty activities, such as walking long distances, than on easy activities in this study.

In this study, the cut-off values of usual walking speed for predicting ADL difficulty at higher, middle, and lower levels were 83.7, 75.5, and 75.1 m/min, respectively. These values were much higher compared to values reported previously, possibly because previous studies assessed ADL dependency in community populations. One study reported that usual walking speeds of 1.25 m/s (75.0 m/min) and 1.07 m/s (64.2 m/min) predict the onset of basic ADL dependency in men and women, respectively, among a Japanese community population aged 65 to 74 years with no ADL dependency [36]. In order to prevent ADL difficulty, higher physical functioning than that needed to prevent ADL dependency might be required. Therefore, the cut-off values obtained in this study might only be applicable to ambulatory HD outpatients.

Alavi et al. [37] reported that the ADL score is associated with age, gender, and education in hemodialysis and transplant patients. To the best of our knowledge, however, the present study is the first to examine determinants of ADL difficulty related to lower extremities after adjusting for confounders in HD patients. Walking speed and depressive symptoms, both predictors of ADL difficulty, have been reported to improve with adequate exercise training in HD patients [38, 39]. Thus, exercise

training may help prevent the onset of ADL difficulty by improving walking speed and depressive symptoms.

This study has some limitations worth noting. First, our study might lack general applicability due to the small sample size and the single-center study design, which included only Japanese HD patients. Second, this study was a cross-sectional study, so a longitudinal study should be carried out in the future to investigate changes in ADL difficulty, physical functions, and depressive symptoms to examine further the determinants of ADL difficulty in HD patients. Third, only CES-D was used to evaluate depressive symptoms. More detailed evaluation including cognitive function will be necessary in the future.

Conclusions

This cross-sectional study revealed that a slow walking speed and old age are significantly and independently associated with ADL difficulty. The presence of depressive symptoms was significantly and independently associated with ADL difficulty at the higher level of difficulty in ambulatory HD patients. In addition, cut-off values of 83.7, 75.5, and 75.1 m/min for usual walking speed predicted the onset of ADL difficulty at higher, middle, and lower levels, respectively.

Additional files

Additional file 1: Table S1. Twelve items of the questionnaire on perceived mobility difficulty for HD patients. HD, hemodialysis. (XLSX 9 kb)

Additional file 2: Table S2. Clinical characteristics, motor function, ADL dependency, and ADL difficulty of study subjects. Data are presented as mean ± standard deviation or number of subjects. *ADL items with higher level difficulty included "walking up two flights of stairs," "walking 1 km," "walking 600 m," and "rising from the floor." †ADL items with middle level difficulty included "walking down two flights of stairs," "walking 300 m," "walking up one flight of stairs," and "sitting down on the floor." ‡ADL items with lower level difficulty included "walking 20 m quickly," "walking down one flight of stairs," "walking 100 m," and "rising from a chair." BMI, body mass index: HD, hemodialysis; ADL, activities of daily living. (XLSX 17 kb)

Additional file 3: Table S3. Univariate and multivariate logistic regression analyses on ADL difficulty. Univariate and multivariate logistic regression analyses were performed with ADL difficulty as a dependent variable and age, male sex, blood hemoglobin concentration, serum albumin concentration, comorbidity index, depression symptoms, maximum leg strength, one-leg standing time, and usual walking speed as independent variables for each level. *ADL items with higher level difficulty included "walking up two flights of stairs," "walking 1 km," "walking 600 m," and "rising from the floor." †ADL items with middle level difficulty included "walking down two flights of stairs," "walking 300 m," "walking up one flight of stairs," and "sitting down on the floor." ‡ADL items with lower level difficulty included "walking 20 m quickly," "walking down one flight of stairs," "walking 100 m," and "rising from a chair." ADL, activities of daily living; OR, odds ratio; CI, confidence interval. (XLSX 15 kb)

Abbreviations

ADL: Activities of daily living; AUC: Area under the curve; BMI: Body mass index; CES-D: Center for Epidemiological Studies Depression Screening Index; CI: Confidence interval; FIM: Functional Independence Measure; HD: Hemodialysis; OR: Odds ratio; ROC: Receiver Operating Characteristic

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Availability of data and materials

We decided not to share the data in our study because all data are thoroughly described and reflected in the accompanying tables and figures (all relevant data are within the paper).

Authors' contributions

TW, TK, NM, YM, RM, YT, AY, and AM analyzed and interpreted the patient data regarding ADL difficulty and contributed significantly to the preparation of the manuscript. KY, MH, and TS performed measurements of motor function, depressive symptom, ADL dependency, and ADL difficulty. All authors read and approved the final manuscript.

Ethics approval and consent to participate

This study was approved by the Ethics Committee of Kitasato University School of Allied Health Sciences and was conducted in accordance with the standards set forth by the latest revision of the Declaration of Helsinki. All patients received a detailed explanation of the study protocol and provided informed consent.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

Publisher's Note

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