Japanese Journal of Physical Therapy for Diabetes Mellitus
OPEN ACCESS

Original article

Relationship between physical activity and step count of patients receiving dialysis: A pilot study

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ABSTRACT

【Background/Objective】Evaluation of physical activity have been recommended as part of routine care in hemodialysis patients. There are many direct ways to evaluate physical activity measured by a 3-axis acceleration sensor. Although, direct way to evaluate physical activity limit the feasibility or practicability. Therefore, it may be useful to simply measure the amount of physical activity through an interview with a questionnaire since this may be completed during the time required for dialysis treatment. The aim was to explore the relationship between the amount of indirectly measured physical activity (self-reported by questionnaire) and physical activity measured directly by an accelerometer.

【Method】Single center pilot study design was employed. Twenty-seven patients receiving outpatient dialysis completed the study. A 3-axis accelerometer assessed the number of steps, which was considered a direct measurement of physical activity. Indirect assessment of physical activity was measured using the International Physical Activity Questionnaire (IPAQ short form, IPAQ-SF) to find the total metabolic equivalents (METs). The relationship between the number of steps and METs was analyzed.

【Results】In all patients, no significant correlation was observed between the number of steps and total METs on both non-dialysis and dialysis days. However, when dividing the number of steps by 3700 steps on non-dialysis day, the 'over 3700 steps' group had a strong correlation between the number of steps and total METs on non-dialysis day ($r = 0.81$, $p < 0.05$).

【Discussion】This study showed that the relationship between indirect evaluation of physical activity by a questionnaire (IPAQ-SF) and direct evaluation of physical activity (step count) in hemodialysis patients. The IPAQ-SF may only be applicable to indirectly measure physical activity in elderly patients receiving dialysis who have activity levels over 3700 steps on non-dialysis days.

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Key words:
hemodialysis, Physical activity, accelerometer

First submitted Dec. 8. 2021
Accepted Feb. 7. 2022

Introduction

Physical activity has been reported to be a factor that regulates the prognosis of hemodialysis patients. According to previous reports in Japanese patients receiving hemodialysis, high daily physical activity levels are necessary to maintain the survival rate[1,2]. In fact, maintaining a high amount of physical activity has a strong influence on exercise therapy and comprehensive renal rehabilitation, which include activities of daily living and quality of life in hemodialysis patients. Further, physical activity is also useful as an outcome measure[3,4]. Therefore, The National Kidney Foundation Kidney Disease Outcomes Quality Initiative Guidelines formally recommend that evaluation of physical activity should be measured as part of routine care in hemodialysis patients[5].

There are many direct ways to evaluate physical activity level, including the total time of an activity and its intensity, or the number of steps per day measured by a 3-axis acceleration sensor. Physical activity level can also be indirectly measured using questionnaires or interviews. Many research studies have used accelerometers to directly assess the amount of physical activity[1,2,3,4]. Of note, there are more than 330,000 dialysis patients in Japan[6], and there are many dialysis treatment facilities, including outpatient clinics, acute care hospitals, and rehabilitations centers; this leads to difficulties in directly measuring the physical activity levels of all patients using accelerometers. In other words, differences in these environments may limit the feasibility or practicability of using accelerometers or other devices to assess physical activity. Therefore, it may be useful to simply measure the amount of physical activity through an interview with a questionnaire since this may be completed during the time required for dialysis treatment. However, the relationship between the indirect assessment of physical activity by a questionnaire and direct assessment of physical activity using an accelerometer (step count) has not been completely elucidated in hemodialysis patients of japan. Thus, the purpose of this study was to determine the relationship between the amount of physical activity indirectly measured by a questionnaire and the amount of physical activity directly measured using an accelerometer in patients receiving dialysis in japan.

Methods

Subjects and Eligibility

Seventy-two subjects who underwent dialysis treatment at a single outpatient dialysis facility between October 2016 and February 2017 were enrolled. The inclusion criteria were patients in a stable disease state regarding renal replacement therapy (3 months after the introduction of dialysis treatment) and who were authorized by their physicians to undergo rehabilitation assessments. Those who did not agree to participate in this study; could not have their activity level evaluated by interview due to declining cognitive function; required assistance for walking; removed the accelerometer frequently during the evaluation period and refused reassessment; and with a free gait speed of less than 0.8 m/sec as a suspicion of sarcopenia[7] and limited community ambulation[8] were excluded (Fig. 1). After enrollment, subjects completed the assessment of physical function and physical activity by questionnaire and accelerometer. Subjects answered the questionnaire of physical activity during dialysis treatment. To evaluate the characteristics of subjects,

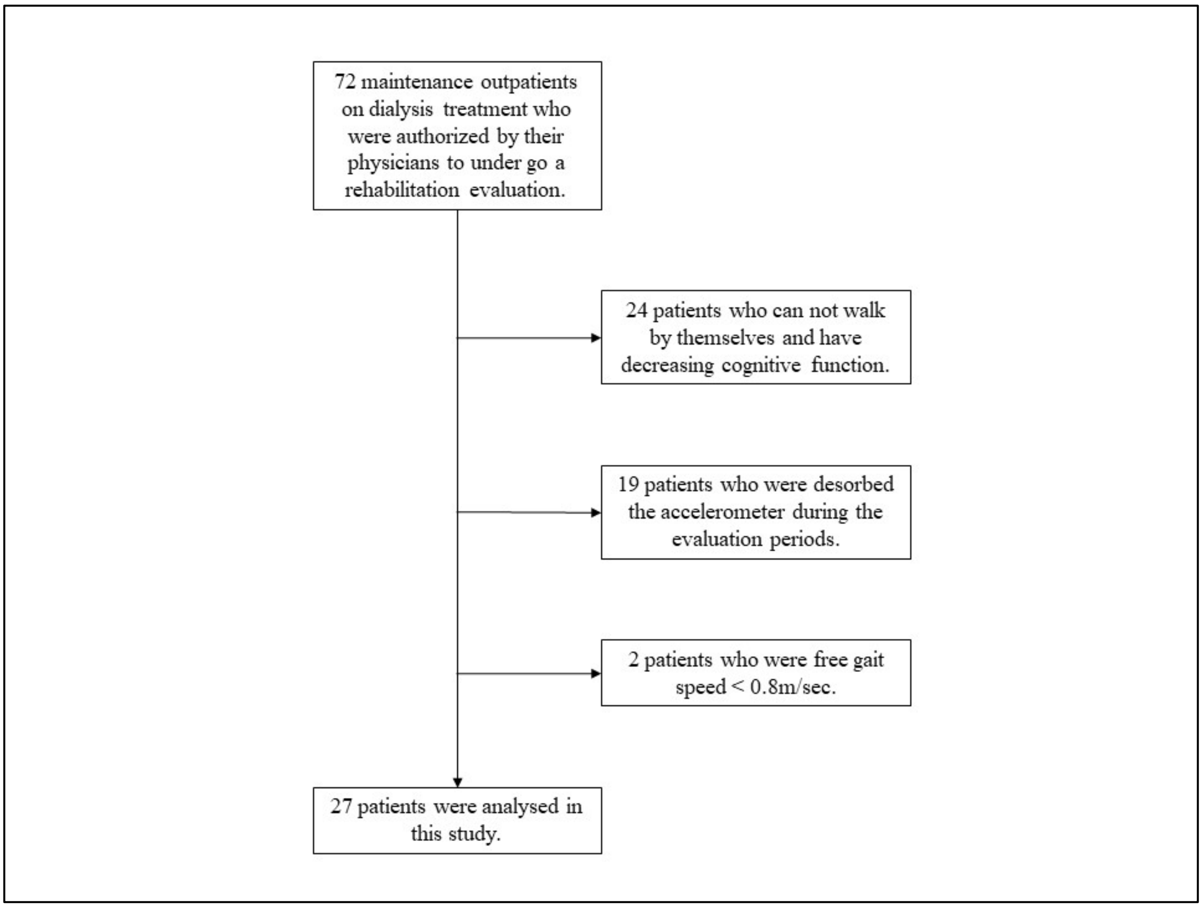

Figure 1. Flow chart of subject selection

age, gender, dry weight, body mass index (BMI), complication such as diabetes mellitus, cardiovascular disease, orthopedic disease, admission past three months, serum albumin (Alb), serum hemoglobin (Hb), C-reactive protein (CRP), and dialysis vintage were also assessed.

This study was conducted with the approval of the research ethics review committee of our institution (approval number: 16-Io-155). Written informed consent was obtained from all participants included in this study.

Direct assessment of physical activity (number of steps) by accelerometer

To directly assess physical activity, the number of steps was measured with a 3-axis accelerometer (Active style Pro, HJA-750C, by OMRON, Tokyo). Subjects wore the accelerometer for one week, divided into 3 dialysis days and 4 non-dialysis days. They were instructed to wear the accelerometer during 7 days except for water-based activities, such as during bathing. We calculated the number of steps per week, 4 non-dialysis days and 3 dialysis days.

Indirect assessment of physical activity (total physical activity time) by questionnaire

For the indirect assessment of physical activity, we calculated the total physical activity time using the

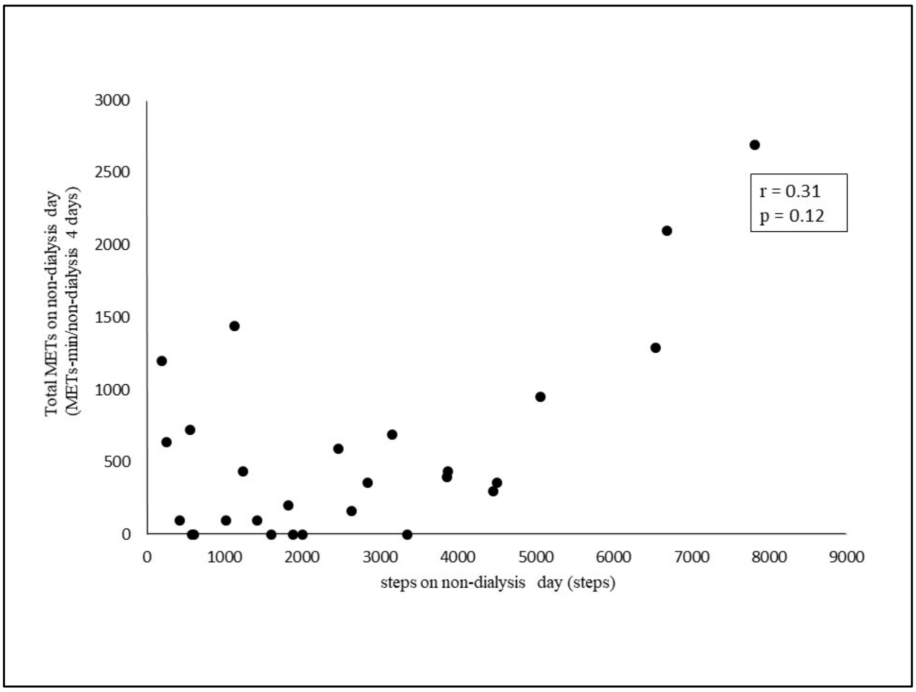

Figure 2. Scatterplot between steps on non-dialysis days and total METs (assessed by questionnaire) on non-dialysis days

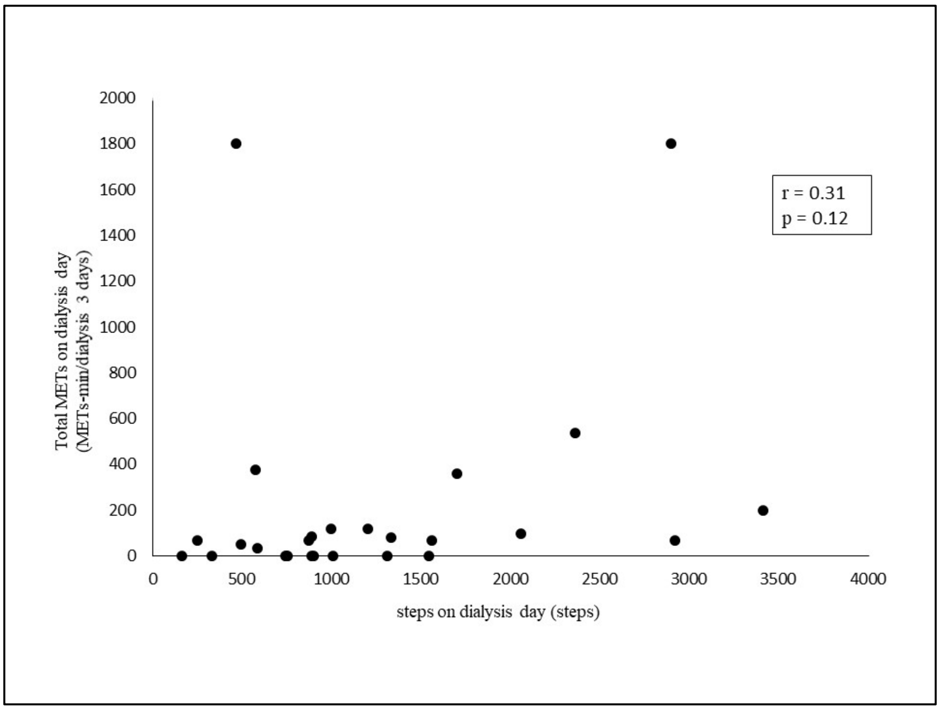

Figure 3. Scatterplot between steps on dialysis days and total METs (assessed by questionnaire) on dialysis days

International Physical Activity Questionnaire (IPAQ short form, IPAQ-SF)[9]. The IPAQ-SF measures the time of walking intensity (3.3 Metabolic Equivalents; MET), time of moderate intensity activities (4.0 MET), and time of vigorous intensity activities (8.0 MET) as below:

Total physical activity METs (total MET, minutes) = (8.0 vigorous intensity activity minutes* days) + (4.0* moderate intensity activity minutes* days) + (3.3* walking minutes* walking days)*

In this study, the total METs were calculated separately for dialysis days (3 days) and non-dialysis days (4 days).

Measurement of physical function

Physical function was measured using grip strength, free gait speed, and the short physical performance battery (SPPB). Grip strength was measured using the Smedley type dynamometer (101 HATS), as proposed by the Ministry of Education, Culture, Sports, Science and Technology in Japan. Free gait speed was calculated as 10-m walking speed (m/sec)[3]. The SPPB consisted of a standing balance test, chair standing test (5 times), and a 4-m gait test[10]. Grip strength, gait speed, and SPPB were measured before entering the dialysis treatment room.

Statistical analysis

The Shapiro-Wilk test was used to test the normality of values. The relationship between the number of steps (measured by accelerometer) and total METs (calculated by IPAQ-SF) was analyzed by Spearman's rank correlation coefficient. Subject characteristics, physical function, physical activity were compared with the Mann-Whitney U test. In addition, patients were divided into two groups depending on the average number of steps on non-dialysis days; the cutoff value was 3,700 steps, based on a previous study[11] about relative mortality in Japanese hemodialysis outpatients. All statistical analysis was conducted using SPSS ver. 25 for Windows. The significance level was set as $p < 0.05$.

Results

Twenty-seven subjects were included in final analysis (Figure 1). No normality was observed in the number of steps, total METs, CRP, grip, SPPB, and dialysis vintage.

In all patients, no significant correlation was found between the number of steps and the total METs on both non-dialysis and dialysis days (Figure 2, 3). However, when the non-dialysis days were divided into two groups ('over 3700 steps' and 'under 3700 steps' groups), the 'over 3700 steps' group had a strong correlation between the number of steps and the total METs on non-dialysis days ($r = 0.81$, $p < 0.05$). Conversely, there was no significant correlation between these measures in the 'under 3700 steps' group (Table 1, 2).

Table 3 shows the characteristics, physical function, and physical activity levels of all subjects. There were no significant differences characteristics and physical function. Subjects with under 3700 steps on non-dialysis days had significantly fewer steps on non-dialysis and dialysis days and lower total METs on non-dialysis days than those subjects with over 3700 steps group on non-dialysis days ($p < 0.05$).

Discussion

This study showed that there was no relationship

Table 1. Correlation coefficient between steps on non-dialysis day and other variables

	All patients			≥3,700 steps group			< 3,700 steps group		
	r	*p* - value	95%CI	*r*	*p* - value	95%CI	*r*	*p* - value	95%CI
Age	-0.19	0.36	-0.53-0.2	-0.65	0.08	-0.93-0.1	-0.21	0.39	-0.61-0.27
BMI	-0.12	0.57	-0.48-0.27	0.34	0.41	-0.48-0.84	-0.15	0.58	-0.57-0.33
Dialysis vintage	-0.10	0.64	-0.46-0.29	-0.14	0.74	-0.77-0.63	-0.03	0.9	-0.48-0.43
Total MET-minutes/NHD	0.31	0.12	-0.08-0.62	0.81	0.02*	0.24-0.96	-0.22	0.37	-0.61-0.26
Total MET-minutes/HD	0.37	0.06	-0.01-0.66	0.04	0.93	-0.64-0.72	-0.23	0.34	-0.62-0.25

*: $p < 0.05$

r: Correlation coefficient, 95%IC: 95% Confidence Interval

BMI: Body Mass Index, NHD: Non Hemodialysis Day, HD: Hemodialysis Day, MET: Metabolic equivalents

Table 2. Correlation coefficient between steps on dialysis day and other variables

	All patients			≥3,700 steps group			< 3,700 steps group		
	r	*p* - value	95%CI	*r*	*p* - value	95%CI	*r*	*p* - value	95%CI
Age	0.05	0.81	-0.34-0.42	0.08	0.84	-0.66-0.74	0.15	0.54	-0.33-0.57
BMI	-0.01	0.72	-0.39-0.37	-0.01	0.99	-0.71-0.7	0.07	0.23	-0.4-0.51
Dialysis vintage	-0.02	0.31	-0.4-0.36	0.05	0.32	-0.68-0.73	-0.30	0.98	-0.66-0.18
Total MET-minutes/NHD	0.36	0.94	-0.02-0.65	0.11	0.91	-0.65-0.76	0.27	0.21	-0.21-0.65
Total MET-minutes/HD	-0.20	0.06	-0.54-0.19	-0.41	0.8	-0.87-0.41	0.01	0.27	-0.45-0.46

r: Correlation coefficient, 95%IC: 95% Confidence Interval

BMI: Body Mass Index, NHD: Non Hemodialysis Day, HD: Hemodialysis Day, MET: Metabolic equivalents

Table 3. Comparison of patient characteristics, physical function, and physical activity between groups with ≥ 3700 steps and < 3700 steps on non-dialysis days

Variable	All patients (n = 27)	≥3700 steps group (n = 8)	< 3700 steps group (n = 19)	*p* - value	
Characteristics					
Age (y)	75.3 (7.3)	75.0 (8.23)	75.4 (7.12)	0.82 [a)]	
Sex (female)	14 (52%)	5 (62%)	9 (47%)	0.68 [c)]	
Diabetes Mellitus (%)	7 (26%)	2 (25%)	5 (26%)	0.81 [c)]	
Cardiovascular disease (%)	3 (11%)	0 (0%)	3 (16%)	0.53 [c)]	
Orthopedic disease (%)	5 (19%)	1 (13%)	4 (21%)	0.99 [c)]	
Admission past three months (%)	3 (11%)	0 (0%)	3 (16%)	0.53 [c)]	
Dry weight (kg)	53.3 (9.7)	51.5(10.1)	54.1 (9.67)	0.70 [a)]	
BMI (kg/m^2)	20.9 (2.22)	20.4 (2.21)	21.2 (2.24)	0.42 [a)]	
Serum Albumin (g/dL)	3.36 (0.26)	3.38 (0.21)	3.35 (0.28)	0.94 [a)]	
Serum hemoglobin (g/dL)	11.0 (0.7)	11.1 (0.71)	11.0 (0.73)	0.94 [a)]	
Serum C-reactive protein (mg/dL)	0.09 (0.05 - 0.17)	0.17 (0.09 - 0.23)	0.09 (0.05 - 0.13)	0.22 [b)]	
Dialysis vintage (year)	8 (5.0 – 15.0)	11.5 (4.75 - 11.8)	8.00 (5.50 - 17.5)	0.66 [b)]	
Physical Functioning					
Hand grip (kg)	23.1 (6.1)	20.7 (6.59)	24.2 (5.71)	0.13 [a)]	
Gait speed (m/sec.)	1.13 (0.2)	1.16 (0.25)	1.12 (0.18)	0.53 [a)]	
SPPB (point)	11 (10.8 - 12)	12 (11.8 - 12)	11 (10.3 - 11)	0.06 [b)]	
Physical Activity					
Steps on NHD	2665.3 (1025.0 - 3871.0)	4781.5 (4307.5 - 6571.3)	1420.0 (594.5 - 2231.5)	0.00 [b)]	*
Steps on HD	902.0 (587.0 - 1564.0)	1812.5 (899.0 - 2502.0)	874.0 (541.0 - 1260.5)	0.03 [b)]	*
Total MET-minutes/NHD	358.0 (99.0 – 720.0)	695.0 (386.3 - 1493.3)	159.0 (0 - 615.0)	0.02 [b)]	*
Total MET-minutes/HD	66.0 (0 - 120)	90.8 (66.0 - 242.8.0)	33.0 (0-100.0)	0.11 [b)]	

*: $p < 0.05$

[a)] Values are expressed as an average (SD) and the p-value was calculated by an unpaired t test.

[b)] Values are expressed as a median (25th %tile – 75th %tile) and the p-value was calculated by a Mann-Whitney's test.

[c)] Values are expressed as a number (%) and the p-value was calculated by a χ^2 test.

BMI, body mass index; MET, metabolic equivalents; SD, standard deviation; SPPB, short physical performance battery, NHD: Non Hemodialysis Day, HD: Hemodialysis Day between indirect evaluation of physical activity by a questionnaire (IPAQ-SF) and direct evaluation of physical activity (step count) in hemodialysis patients. On the other hand, there was the association between IPAQ-SF and step count was high in hemodialysis patients who have 3,700 or more steps on non-dialysis days. Using the IPAQ-SF questionnaire to assess physical activity was a valid method only in patients with more than 3,700 steps on non-dialysis days. In other words, the IPAQ assessment of physical activity level was not associated with the number of steps measured by accelerometer in hemodialysis patients with low physical activity levels on both dialysis and non-dialysis days.

Previous studies of Japanese hemodialysis patients have not reported the relationship between the direct and indirect evaluations of physical activity using accelerometer and the IPAQ, respectively. In a study examining the IPAQ-SF for Japanese patients with diabetes, the correlation coefficient between the energy expenditure measures by accelerometer was 0.69[12]. In addition, in a study of patients with metabolic syndrome and Hemodialysis, a moderate correlation coefficient (0.46 to 0.62) was observed[13,14]. Recently, Lou et al. investigated that an association between indirect assessment of physical activity by a IPAQ-SF and direct assessment of physical activity by a step count in Chinese Hemodialysis patients[15]. The result of their study showed that a relationship between IPAQ-SF and step count, but the age and sex bias should be taken into account in interpreting the result. Therefore, it is necessary to consider whether it is appropriate to evaluate physical activity level by a questionnaire according to a validity analysis for individual attributes and physical characteristics.

A number of hemodialysis patients in japan is aging, and elderly hemodialysis patients are more likely to complain somatic symptoms such as fatigue[6,16]. Hemodialysis patients with fatigue adjusted the timing and intensity of their activities to accommodate their fatigue[17]. Because the IPAQ is influenced by respondents' recall and honesty, it may overestimate actual physical activity, especially low and high intensity activity[18,19,20]. We speculate that the indirect assessment by the IPAQ did not sufficiently evaluate the adjustment of physical activity patterns of hemodialysis patients. In fact, our study results showed that it was difficult to indirectly predict (by questionnaire) the activity levels of patients with extremely low activity (less than 3,700 steps/day), who were found to have relatively high mortality[11]. The average steps of patients who were below 3,700 steps/day were about 1,400 steps/day in this study. It has been reported that elderly dialysis patients lie in bed for long periods of time[21]. This suggests that their sitting time is extremely longer than their walking time per day. Thus, it is considered inappropriate to assess the amount of physical activity for these patients (who have extended lengths of inactivity time) using the IPAQ-SF because the total METs are based on walking intensity (3.3 METs).

Previous study demonstrated that somatic symptoms independently influence low physical activity by assessed by pedometer[22]. In the future, it is interesting to investigate the validity of the indirect assessment of physical activity by a questionnaire in hemodialysis patients who have low somatic discomfort.

This study was conducted with some limitations. First, the sample size was very small, and so, confounding factors affecting the relationship between the number of steps and the METs from the IPAQ-SF were not adjusted. Second, subjects who older age (> 75 age) were chosen in this study. Third, this study was limited to a single center. In order to generalize the findings for maintenance hemodialysis outpatients, additional research with an increased number of subjects, recruited relatively subject who younger age and, large-scale prospective cohort studies is required. Finally, the reliability of repeated measurements of the IPAQ-SF has not been sufficiently studied.

Conclusion

This study showed that the relationship between indirect evaluation of physical activity by a questionnaire (IPAQ-SF) and direct evaluation of physical activity (step count) was high in hemodialysis patients who have 3,700 or more steps on non-dialysis days. The IPAQ-SF may only be applicable to indirectly measure physical activity in elderly patients receiving dialysis who have activity levels over 3700 steps on non-dialysis days.

Conflict of Interest

The authors declare that they have no competing interests.

Acknowledgments

The authors gratefully acknowledge the support and participation of the patients in this study.

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