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Original Article

Relationship between Sedentary Behavior and All-cause Mortality in Japanese Chronic Hemodialysis Patients: A Prospective Cohort Study

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We investigated the relationship between sedentary behavior and all-cause mortality in patients undergoing hemodialysis. A total of 71 patients (39 men, 32 women, aged 72.1 ± 11.7 years) were enrolled in this longitudinal study. Their sedentary behavior was measured using a tri-accelerometer that provides relative values per daily wearing time. We classified the sedentary behavior time into 2 groups (under the median: short-sedentary behavior (SB) group; over the median: long-SB group) and compared the groups' clinical parameters. We compared the groups' survival rates by using Kaplan-Meier curves and the log-rank test, and we performed multivariate analyses by a Cox-proportional hazard model to evaluate the relationship between the sedentary behavior and the survival rate. Twenty patients (28.2%) died during the observation period. The survival rate of the short-SB group was significantly higher than that of the long-SB group. Sedentary behavior was thus an important factor for all-cause mortality even after adjusting for confounding factors by a Cox-proportional hazard model. Sedentary behavior is closely linked to all-cause mortality, especially total days and non-hemodialysis days, and reducing sedentary behavior may be beneficial to reduce the all-cause mortality of patients on chronic hemodialysis.

Key words: sedentary behavior, hemodialysis, mortality, physical activity

In Japan, both the number of chronic hemodialysis patients and the average age of such patients are increasing (The Japan Society for Dialysis Therapy, http://docs.jsdt.or.jp/overview/pdf2017/p015.pdf, accessed on Sep. 15, 2018). Although the survival rate of chronic hemodialysis patients is improving due to recent medical advances (http://docs.jsdt.or.jp/overview/pdf2014/p029.pdf. accessed on Sep. 15, 2018), the patients' prognosis is still poor [1,2]. Improvements in the quality of life (QOL) and all-cause mortality are thus considered to be important for patients on chronic hemodialysis.

Sedentary behavior, defined as physical activity of ≤ 1.5 metabolic equivalents (METs) in a reclining or sitting posture [3], is well known to be closely linked to all-cause mortality [4-13]. In patients on chronic dialysis, nutrition [14], physical activity [15-17], physical function [18], muscle mass [19], muscle strength [19,20], and metabolic syndrome [21] have been reported to be associated with all-cause mortality. However, to our knowledge, the relationship between sedentary behavior and all-cause mortality in Japanese hemodialysis patients has not been established. In our

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prior investigations of patients on chronic hemodialysis, the patients' physical activity was closely associated with their health-related quality of life (HRQOL) [22, 23]. In a cross-sectional study, sedentary behavior was found to be an important factor for HRQOL independent of physical activity [24].

We thus conducted the present longitudinal study to evaluate the relationship between sedentary behavior and all-cause mortality in Japanese patients on chronic hemodialysis, and our analyses revealed that the sedentary behavior in this cohort was closely linked to the patients' all-cause mortality.

Patients and Methods

Patients. Among 183 patients on chronic hemodialysis at our hospital, a total of 71 patients (39 men and 32 women; aged 72.1 ± 11.7 years; duration of hemodialysis, 88.2 ± 87.7 months) voluntarily enrolled in this longitudinal study conducted from 2013 to 2018. The 71 enrolled patients met the following criteria: (1) they underwent chronic hemodialysis at Innoshima General Hospital, Onomichi, Japan, between September 2013 and September 2018; (2) they underwent measurements of their physical activity including sedentary behavior using a tri-accelerometer as part of a previous study [24]; and (3) they provided written informed consent to participate in the present study.

Ethical approval for the present study was obtained from the ethical committee at Innoshima General Hospital, Onomichi, Japan (H25-2-27, H26-1-23, H26-12-16, H27-12-25, H28-12-9, and H29-12-4).

Clinical parameters and measurements. We evaluated the following clinical parameters as described previously [24]: sex; age (years); height (cm); body weight (dry weight) (kg); duration of hemodialysis (months); body mass index (BMI) (kg/m^2) (calculated as body weight (kg)/[height (m)]^2); and the date and reason for dialysis cancellation. We used the patients' clinical records to determine their values of albumin (g/mL), fasting blood glucose (mg/mL), triglyceride (mg/dL), HDL-cholesterol (mg/dL), and hemoglobin (g/dL) as blood sample data, and diabetes mellitus (DM), hypertension, hyperlipidemia, low back pain (*i.e.*, osteoarthritis), and knee pain (*i.e.*, osteoarthritis) as complicating diseases. Details of low back pain and knee pain could not be evaluated.

The patients' physical activity (including sedentary behavior) was measured using a tri-accelerometer (Active style Pro: HJA-350IT; Omron, Kyoto, Japan) as described previously [24]. We evaluated the patients' sedentary behavior as the relative values (%) per daily wearing time, and based on the results we categorized the patients into two groups: a short-sedentary behavior (SB) group (under the median SB value) and a long-SB group (over the median). We defined the days that the patients underwent hemodialysis treatment as the hemodialysis days, and the other days as the non-hemodialysis days, and we defined "total days" as the sum of hemodialysis days and non-hemodialysis days.

Statistical analysis. Data are expressed as the mean ± standard deviation (SD). We compared the clinical parameters between the short-SB and long-SB groups by using the unpaired *t*-test and chi-square test, where $p < 0.05$ was considered to be significant. We obtained Kaplan-Meier curves and used the log-rank test to compare the survival rates of the short- and long-SB groups. We performed a multivariate analysis and Cox-proportional hazards regression analysis to evaluate the relationship between the survival rate and sedentary behavior to adjust for confounding factors. The statistical analyses were performed using JMP 13.0 software (SAS, Cary, NC, USA).

Results

The clinical profiles of the enrolled 71 patients on chronic hemodialysis are summarized in Table 1. The average age at the first hemodialysis was 61.6 ± 14.9 years. The reason for the hemodialysis was diabetic nephropathy in 22 patients (31.0%). The average duration of the patients' sedentary behavior was 74.0 ± 13.6% total days, 74.7 ± 14.1% hemodialysis days, and 73.4 ± 14.3% non-hemodialysis days (Table 2). A total of 20 patients (28.2%) died during the follow-up period. The causes of death were sudden death (n = 3), pneumonia (n = 2), cerebral infarction (n = 2), heart failure (n = 2) and others (n = 11). The average follow-up period was 3.0 ± 1.7 years.

We compared the clinical parameters between the short- and long-SB groups of patients on chronic hemodialysis (Table 3). There were significant differences in the sex, age, height, body weight, duration of hemodialysis, and history of diabetes mellitus between the short-SB and long-SB groups defined based on total days. When the groups were defined based on the hemodialysis days, there were also significant between-group differences in the sex, age, body weight, and low back pain. When they were defined based on non-hemodialysis days, the sex, age, height, and history of diabetes mellitus in the short-SB group were significantly different from those in the long-SB group.

The cumulative survival rate of the 71 patients was 91.6% at 1 year, 79.3% at 3 years and 59.8% at 5 years. The survival rate of the short-SB group was significantly higher than that of the long-SB group by survival analysis (total days, $p = 0.028$; hemodialysis days, $p = 0.016$; non-hemodialysis days, $p = 0.024$). The hazard ratio was 2.83 (95% confidence interval [CI]: 1.11-7.32) for

Table 1 Clinical characteristics of patients on hemodialysis

Women	32 (45.1%)
Age (years)	72.1 ± 11.7
over 65 years	56 (78.9%)
Height (cm)	155.5 ± 9.3
Body weight (dry weight) (kg)	53.7 ± 10.7
Body mass index (kg/m^2)	22.1 ± 3.4
Duration of hemodialysis (months)	88.2 ± 87.7
Blood sample	
Albumin (g/mL)	3.8 ± 0.4
Fasting blood glucose (mg/dL)	136.1 ± 46.3
Triglyceride (mg/dL)	111.6 ± 72.3
HDL-cholesterol (mg/dL)	55.3 ± 17.2
Hemoglobin (g/dL)	11.1 ± 0.9
Complicating disease	
Diabetes mellitus	30 (42.2%)
Hypertension	66 (92.9%)
Hyperlipidemia	33 (46.5%)
Low back pain	27 (38.0%)
Knee pain	14 (19.7%)

Values are shown as mean ± SD or *n* (%)

Table 2 Physical activity in patients on hemodialysis

	Mean ± SD	Minimum	Maximum
Total days			
SB (%)	74.0 ± 13.6	32.2	95.4
LPA (%)	24.4 ± 12.6	0.1	55.6
MVPA (%)	1.8 ± 2.4	0.0	15.1
Hemodialysis days			
SB (%)	74.7 ± 14.1	31.4	94.2
LPA (%)	23.7 ± 13.1	0.1	56.3
MVPA (%)	1.8 ± 2.4	0.0	15.9
Non-hemodialysis days			
SB (%)	73.4 ± 14.3	32.8	96.5
LPA (%)	25.0 ± 13.2	0.1	57.9
MVPA (%)	1.8 ± 2.6	0.0	14.5

SB: Sedentary behavior, ≤1.5 Metabolic equivalents (METs)
LPA: Light intensity physical activity, 1.6–2.9 METs
MVPA: Moderate-to-vigorous intensity physical activity, 3.0 METs ≤

Table 3 Comparison of clinical parameters between short-SB and long-SB in patients on hemodialysis

Variables	Total days			Hemodialysis days			Non-hemodialysis days		
	Short-SB (n=35)	Long-SB (n=36)	*p* value	Short-SB (n=35)	Long-SB (n=36)	*p* value	Short-SB (n=35)	Long-SB (n=36)	*p* value
Women (%)	22 (62.9%)	10 (27.8%)	**0.003**	20 (57.1%)	12 (33.3%)	**0.044**	22 (62.9%)	10 (27.8%)	**0.003**
Age (years)	68.3 ± 1.9	75.7 ± 1.9	**0.007**	69.2 ± 1.9	74.8 ± 1.9	**0.042**	68.3 ± 1.9	75.7 ± 1.9	**0.007**
Height (cm)	153.1 ± 1.5	157.9 ± 1.5	**0.027**	154.0 ± 1.6	157.0 ± 1.5	0.164	153.2 ± 1.5	157.8 ± 1.5	**0.032**
Body weight (dry weight) (kg)	50.2 ± 1.7	57.0 ± 1.7	**0.007**	50.8 ± 1.8	56.4 ± 1.7	**0.027**	51.9 ± 1.8	55.4 ± 1.8	0.180
Body mass index (kg/m^2)	21.4 ± 0.6	22.8 ± 0.6	0.088	21.4 ± 0.6	22.8 ± 0.6	0.093	22.0 ± 0.6	22.2 ± 0.6	0.831
Duration of hemodialysis (months)	111.1 ± 14.4	65.9 ± 14.2	**0.029**	99.1 ± 14.8	77.6 ± 14.6	0.304	108.1 ± 14.6	68.9 ± 14.3	0.059
Albumin (g/mL)	3.8 ± 0.1	3.8 ± 0.1	0.833	3.7 ± 0.1	3.8 ± 0.0	0.578	3.8 ± 0.1	3.7 ± 0.1	0.241
Fasting blood glucose (mg/dL)	126.1 ± 7.7	145.9 ± 7.6	0.071	126.8 ± 7.7	145.2 ± 7.6	0.094	128.9 ± 7.8	143.2 ± 7.7	0.193
Triglyceride (mg/dL)	100.1 ± 12.2	122.8 ± 12.0	0.188	112.5 ± 12.3	110.7 ± 12.1	0.917	106.2 ± 12.3	116.8 ± 12.1	0.539
HDL-cholesterol (mg/dL)	59.0 ± 2.9	51.7 ± 2.8	0.075	57.0 ± 2.9	53.6 ± 2.9	0.417	58.2 ± 2.9	52.4 ± 2.9	0.155
Diabetes mellitus	10 (28.6%)	20 (55.6%)	**0.021**	12 (34.3%)	18 (50.0%)	0.180	10 (28.6%)	20 (55.6%)	**0.021**
Hypertension	31 (88.6%)	35 (97.2%)	0.154	32 (91.4%)	34 (94.4%)	0.620	31 (88.57%)	35 (97.2%)	0.154
Hyperlipidemia	15 (44.1%)	18 (50.0%)	0.622	16 (47.1%)	17 (47.2%)	0.989	15 (44.1%)	18 (50.0%)	0.622
Low back pain	12 (35.3%)	15 (41.7%)	0.584	9 (26.5%)	18 (50.0%)	**0.043**	12 (35.3%)	15 (41.7%)	0.584
Knee pain	7 (20.6%)	7 (19.4%)	0.905	8 (25.5%)	6 (16.7%)	0.473	6 (17.7%)	8 (22.2%)	0.632

SB: Sedentary behavior, ≤1.5 Metabolic equivalents (METs)
Bold values indicated statistically significant ($p < 0.05$)
Values are shown as the mean ± SD or *n* (%)
Sedentary behavior was classified into two groups (under median: short-SB, over median: long-SB).

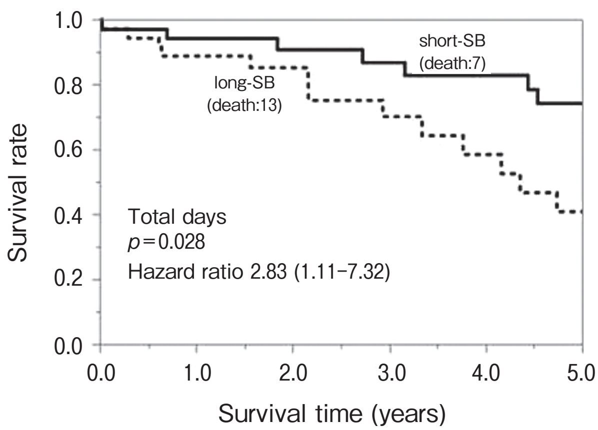
the total days, 2.98 (95%CI: 1.21-8.03) for the hemodialysis days, and 2.79 (95%CI: 1.13-7.49) for the non-hemodialysis days (Fig. 1).

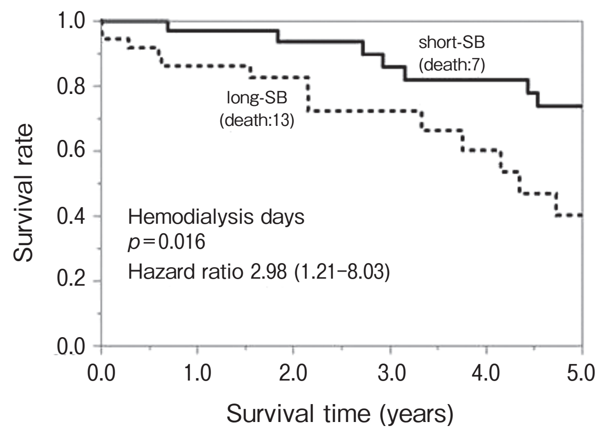
We also observed significant differences in the moderate-to-vigorous intensity physical activity (MVPA: ≥3.0 METs) between the younger patients (<65 years) and the older group (≥65 years) only on non-hemodialysis days. There were also significant differences in both sedentary behavior and low-intensity physical activity (LPA: 1.6-2.9 METs) between the diabetic and non-diabetic patients for only the non-hemodialysis days. Finally, using the Cox-proportional hazard model after adjusting for confounding factors including age and history of diabetes mellitus, we observed that the clinical impact of sedentary behavior on the survival rate was notable, excluding adjustments for sex and age in hemodialysis days (Table 4).

Discussion

This is the first study to investigate the relationship between sedentary behavior evaluated by a tri-accelerometer and all-cause mortality in Japanese patients on chronic hemodialysis, and our analyses demonstrated that sedentary behavior was an important factor for all-cause mortality, especially as measured over total days or non-hemodialysis days.

Concerning the association between sedentary behavior and mortality, too much sitting was reported to be a factor in 3.8% of the all-cause mortality in 54 countries [25]. Another study reported that Japanese people engage in longer sitting times compared to individuals in all other studies examined as measured by the International Physical Activity Questionnaire (IPAQ) [26]. Among Japanese subjects in primary industry, sedentary behavior was reported to be closely associated with mortality [11]. However, there is no prior study





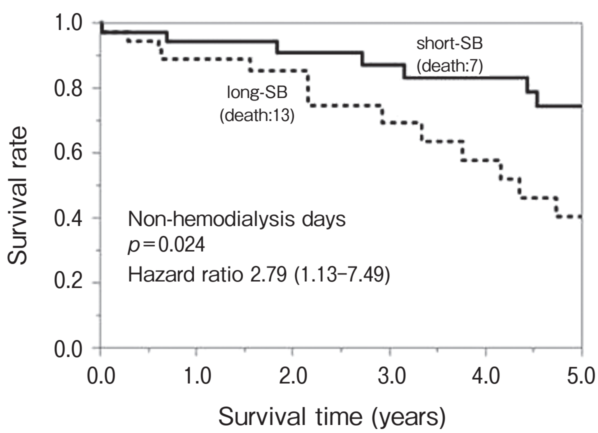


Fig. 1 Kaplan-Meier analysis of survival rate for 71 hemodialysis patients

Table 4 Multivariate analysis for hemodialysis patients' survival rate (Cox-proportional hazard model)

Independent variables	β	95% CI (Lower, Upper)		p value
Total days				
SB (%)	0.0427	0.0051, 0.0843		**0.025**
Sex	0.5967	−2.3438, −0.2076		**0.017**
			Goodness of Model Fit	p = **0.001**
SB (%)	0.0439	0.0044, 0.0857		**0.029**
Age (years)	0.0380	−0.0060, 0.0088		0.093
			Goodness of Model Fit	p = **0.004**
SB (%)	−0.0001	0.0157, 0.0929		**0.005**
Duration of hemodialysis (months)	0.0531	−0.0053, 0.0045		0.976
			Goodness of Model Fit	p = **0.018**
SB (%)	0.0490	0.0105, 0.0896		**0.012**
Albumin (g/mL)	−0.7619	−2.0691, 0.5182		0.250
			Goodness of Model Fit	p = **0.009**
SB (%)	0.0500	0.0106, 0.0921		**0.012**
History of diabetes mellitus	−0.1020	−0.5852, 0.3685		0.670
			Goodness of Model Fit	p = **0.016**
Hemodialysis days				
SB (%)	0.0355	−0.0018, 0.0779		0.063
Sex	0.6223	0.1329, 1.1950		**0.012**
			Goodness of Model Fit	p = **0.002**
SB (%)	0.0358	−0.0023, 0.0784		0.066
Age (years)	0.0424	−0.0013, 0.0922		0.058
			Goodness of Model Fit	p = **0.009**
SB (%)	0.0454	0.0078, 0.0868		**0.017**
Duration of hemodialysis (months)	−0.0010	−0.0053, 0.0045		0.974
			Goodness of Model Fit	p = 0.052
SB (%)	0.0407	0.0030, 0.0826		**0.034**
Albumin (g/mL)	−0.8422	−2.1141, 0.4004		0.189
			Goodness of Model Fit	p = **0.022**
SB (%)	0.0408	0.0028, 0.0836		**0.035**
History of diabetes mellitus	−0.1764	−0.6503, 0.2859		0.453
			Goodness of Model Fit	p = **0.040**
Non-hemodialysis days				
SB (%)	0.0430	0.0069, 0.0833		**0.018**
Sex	0.5871	0.0915, 1.1642		**0.019**
			Goodness of Model Fit	p = **0.001**
SB (%)	0.0450	0.0068, 0.0850		**0.021**
Age (years)	0.0362	−0.0075, 0.0861		0.107
			Goodness of Model Fit	p = **0.003**
SB (%)	0.0536	0.0175, 0.0918		**0.003**
Duration of hemodialysis (months)	−0.0001	−0.0054, 0.0045		0.971
			Goodness of Model Fit	p = **0.012**
SB (%)	0.0500	0.0128, 0.0890		**0.008**
Albumin (g/mL)	−0.7460	−2.0800, 0.5647		0.271
			Goodness of Model Fit	p = **0.006**
SB (%)	0.0516	0.0130, 0.0922		**0.008**
History of diabetes mellitus	−0.0679	−0.5553, 0.4066		0.779
			Goodness of Model Fit	p = **0.011**

CI, Confidence interval; SB, Sedentary behavior, ≤1.5 Metabolic equivalents (METs). Bold values indicate statistically significant ($p < 0.05$).

reporting the relationship between sedentary behavior and mortality in Japanese patients on chronic hemodialysis. Our earlier cross-sectional study revealed a significant relationship between sedentary behavior and HRQOL after adjusting for age, sex, duration of hemodialysis, and history of diabetes mellitus [24].

Concerning the relationship between sedentary behavior and all-cause mortality, there are reports that muscle weakness is strongly associated with an increased mortality risk [19, 20]. A study using electromyography showed no activity of the quadriceps muscle while the subjects were seated [26], and other reports showed that sedentary behavior had a negative effect on lipid metabolism [27, 28] and insulin sensitivity [29]. Moreover, sedentary behavior is reported to be associated with cardiovascular disease [30, 31]. These multiple factors of sedentary behavior may contribute to the increase in all-cause mortality observed in several studies.

The effects of exercise on patients with chronic kidney disease have been described previously [32], and renal rehabilitations such as exercise intervention improved the life-prognosis of patients undergoing hemodialysis [33, 34]. Renal rehabilitation is thus recommended as an effective means to improve the life prognosis in patients undergoing hemodialysis (Japanese Society of Renal Rehabilitation, https://jsrr.jimdo.com/accessed March 8, 2019). Most dialysis patients are elderly, and their physical activity level is low [24, 35-37]. It can be difficult to increase the physical activity of patients on chronic hemodialysis. Although in the present study there was no significant relationship between sedentary behavior and all-cause mortality after adjusting for sex and age for the patients' hemodialysis days, a reduction of sedentary behavior especially on non-hemodialysis days may improve the all-cause mortality of patients on chronic hemodialysis in clinical practice. The lying down for approximately 4-hr that is required on hemodialysis days may affect the relationship between sedentary behavior and the all-cause mortality on hemodialysis days.

Our study has several potential limitations. The sample size was small (n = 71) and the investigation was conducted at only one hospital because of the difficulty evaluating of the physical activity of chronic hemodialysis patients [38]. In addition, the patients' sedentary behavior on their hemodialysis days might not have been accurately evaluated due to the approximately 4-hr period of lying down during the hemodialysis. Finally, we assessed sedentary behavior on only 2-3 hemodialysis days for each patient.

These results suggest that reducing sedentary behavior, especially on patients' non-hemodialysis days, may reduce the all-cause mortality in clinical practice. Further studies using larger samples and including multiple hospitals and prospective intervention studies to improve sedentary behavior are needed for Japanese patients on chronic hemodialysis.

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References

1. Goodkin DA, Bragg-Gresham JL, Koenig KG, Wolfe RA, Akiba T, Andreucci VE, Saito A, Rayner-HC, Kurokawa K, Port FK, Held PJ and Young EW: Association of comorbid conditions and mortality in hemodialysis patients in Europe, Japan, and the US: The Dialysis Outcomes and Practice Patterns Study (DOPPS). J Am Soc Nephrol (2003) 14: 3270–3277.
2. Robinson BM, Bieber B, Pisoni RL and Port FK: Dialysis outcomes and practice patterns study (DOPPS): its strength, limitations, and role in informing practices and policies. Clin J Am Soc Nephrol (2012) 7: 1897–1905.
3. Sedentary Behaviour Research Network: Letter to the editor: standardized use of the terms "sedentary" and "sedentary behaviors". Appl Physiol Nutr Metab (2012) 37: 540–542.
4. O'Hare AM, Tawney K, Bacchetti P and Johansen KL: Decreased survival among sedentary patients undergoing dialysis: Results from the dialysis morbidity and mortality study wave 2. Am J Kidney Dis (2003) 41: 447–454.
5. Koster A, Caserotti P, Patel KV, Matthews CE, Berrigan D, Van Domelen DR, Brychta RJ, Chen KY and Harris TB: Association of sedentary time with mortality independent of moderate to vigorous physical activity. PLoS One (2012) 7: e37696.
6. van der Ploeg HP, Chey T, Korda RJ, Banks E and Bauman A: Sitting time and all-cause mortality risk in 222497 Australian adults. Arch Intern Med (2012) 172: 494–500.
7. Matthews CE, George SM, Moore SC, Bowles HR, Blair A, Park Y, Troiano RP, Hollenbeck A and Schatzkin A: Amount of time spent in sedentary behaviors and cause-specific mortality in US adults. Am J Clin Nutr (2012) 95: 437–445.
8. de Rezende LF, Rodrigues Lopes M, Rey-Lopez JP, Matsudo VK and Luiz Odo C: Sedentary behavior and health outcomes: an overview of systematic reviews. PLoS One (2014) 9: e105620.
9. Schmid D, Ricci C and Leitzmann MF: Associations of objectively assessed physical activity and sedentary time with all-cause mortality in US adults: The NHANES Study. PLoS One (2015) 10: e0119591.
10. Biswas A, Oh PI, Faulkner GE, Bajaj RR, Silver MA, Mitchell MS and Alter DA: Sedentary time and its association with risk disease incidence, mortality, and hospitalization in adults. A systematic review and meta-analysis. Ann Intern Med (2015) 162: 123–132.
11. Kikuchi H, Inoue S, Odagiri Y, Inoue M, Sawada N and Tsugane S: Occupational sitting time and risk of all-cause mortality among

Japanese workers. Scand J Work Environ Health (2015) 41: 519–528.

12. Klenk J, Dallmeier D, Denkinger MD, Rapp K, Koenig W, Rothenbacher D and ActiFE Study Group: Objectively measured walking duration and sedentary behavior and four-year mortality in older people. PLoS One (2016) 11: e0153779.
13. Biddle SJ, Bennie JA, Bauman AE, Chau JY, Dunstan D, Owen N, Stamatakis E and van Uffelen JG: Too much sitting and all-cause mortality: is there a causal link? BMC Public Health (2016) 16: 635.
14. Fujita S, Yamaoka Y, Nagai M, Nakaya T, Hanba Y and Shigematsu T: Analysis of factors affecting the prognosis of a hemodialysis patient − Focusing on albumin and parameter of nutrition −. J Jpn Soc Deal Ther (2010) 43: 453–460 (In Japanese).
15. Matsuzawa R, Matsunaga A, Wang G, KutsunaT, Ishii A, Abe Y, Takagi Y, Yoshida A and Takahira N: Habitual physical activity measured by accelerometer and survival in maintenance hemodialysis patients. Clin J Am Soc Nephrol (2012) 7: 2010–2016.
16. Johansen KL, Kaysen GA, Dalrymple LS, Grimes BA, Glidden DV, Anand S and Chertow GM: Association of Physical Activity with Survival among Ambulatory Patients on Dialysis: The Comprehensive Dialysis Study. Clin J Am Soc Nephrol (2013) 8: 248–253.
17. Shimoda T, Matsuzawa R, Yoneki K, Harada M, Watanabe T, Matsumoto M, Yoshida A, Takeuchi Y and Matsunaga A: Changes in physical activity and risk of all-cause mortality in patents on maintence hemodialysis: a retrospective cohort study. BMC Nephrol (2017) 18: 154.
18. Inaguma D, Tanaka A and Shinjo H: Physical function at the time of dialysis initiation is associated with subsequent mortality. Clin Exp Nephrol (2017) 21: 425–435.
19. Isoyama N, Qureshi AR, Avesani CM, Lindholm B, Bàràny P, Heimbürger O, Cederholm T, Stenvinkel P and Carrero JJ: Comparative associations of muscle mass and muscle strength with mortality in dialysis patients. Clin J Am Soc Nephrol (2014) 9: 1720–1728.
20. Matsuzawa R, Matsunaga A, Wang G, Yamamoto S, Kutsuna T, Ishii A, Abe Y, Yoneki K, Yoshida A and Takahira N: Relationship between lower extremity muscle strength and all-mortality in Japanese patients undergoing dialysis. Phys Ther (2014) 94: 947–956.
21. Sanguankeo A and Upala S: Metabolic syndrome increases mortality risk in dialysis patients: A systematic review and meta-analysis. Int J Endocrinol Metab (2018) 16: e61201.
22. Katayama A, Miyatake N, Nishi H, Uzike K, Sakano N, Hasimoto H and Koumoto K: Evaluation of physical activity and its relationship to health-related quality of life in patients on chronic hemodialysis. Environ Health Prev Med (2014) 19: 220–225.
23. Katayama A, Miyatake N, Nishi h, Uzike K, Hashimoto H, Kurato R and Koumoto K: Relationship between changes in physical activity and changes in health-related quality of life in patients on chronic hemodialysis with 1-year follow-up. Acta Med Okayama (2016) 70: 353–361.
24. Hishii S, Miyatake N, Nishi H, Katayama A, Ujike K, Koumoto K and Hashimoto H: Relationship sedentary behavior and health related quality of life in patients on hemodialysis. Acta Med Okayama (2018) 72: 395–400.
25. Rezende LFM, Sá TH, Mielke GI, Viscondi JYK, Rey-López JP and Gracia LMT: All-Cause Mortality Attributable to Sitting Time Analysis of 54 Countries Worldwide. Am J Prev Med (2016) 51: 253–263.
26. Bauman A, Ainsworth BE, Sallis JF, Hagströmer M, Craig CL, Bull FC, Pratt M, Venugopal K, Chau J, Sjöström M and IPS Group: The Descriptive epidemiology of sitting A 20-country comparison using the International Physical Activity Questionnaire (IPAQ). Am J Prev Med (2011) 41: 228–235.
27. Hamilton MT, Hamilton DG and Zderic TW: Role of low energy expenditure and sitting in obesity, metabolic syndrome, type 2 diabetes, and cardiovascular disease. Diabetes (2007) 56: 2655–2667.
28. Bey L and Hamilton MT: Suppression of skeletal muscle lipoprotein lipase activity during physical inactivity: a molecular reason to maintain daily low-intensity activity. J Physiol (2003) 551: 673–682.
29. Brocklebank LA, Falconer CL, Page AS, Perry R and Cooper AR: Accelerometer-measured sedentary time and cardiometabolic biomarkers: A systematic review. Prev Med (2015) 76: 92–102.
30. Wilmot EG, Edwardson CL, Achana FA, Davies MJ, Gorely T, Gray LJ, Khunti K, Yates T and Biddle SJ: Sedentary time in adults and the association with diabetes, cardiovascular disease and death: systematic review and meta-analysis. Diabetologia (2012) 55: 2895–2905.
31. Henson J, Yates T, Biddle SJ, Edwardson CL, Khunti K, Wilmot EG, Gray LJ, Gorely T, Nimmo MA and Davies MJ: Associations of objectively measured sedentary behavior and physical activity with markers of cardiometabolic health. Diabetologia (2013) 56: 1012–1020.
32. Johansen KL: Exercise in the End-stage Renal Disease Population. J Am Soc Nephrol (2007) 18: 1845–1854.
33. Greenwood SA, Castle E, Lindup H, Mayes J, Waite I, Grant D, Mangahis E, Crabb O, Shevket K, Macdougall IC and MacLaughlin HL: Mortality and morbidity following exercise-based renal rehabilitation in patients with chronic kidney disease: the effect of programme completion and change in exercise capacity. Nephrol Dial Transplant (2018) 1–8.
34. Ouzouni S, Kouidi E, Grekas D and Deligiannis A: Effects of intradialytic exercise training on health-related quality of life indices in haemodialysis patients. Clin Rehabil (2009) 23: 53–63.
35. Shiota K and Hashimoto T: Promotion and support of physical activity in elderly patients on hemodialysis: a case study. J Phys Ther Sci (2016) 28: 1378–1383.
36. Gomes EP, Reboredo MM, Carvalho EV, Teixeira DR, Carvalho LF, Filho GF, de Oliveira JC, Sanders-Pinheiro H, Chebli JM, de Paula RB and Pinheiro Bdo V: Physical activity in hemodialysis patients measured by triaxial accelerometer. Biomed Res Int (2015): 645645.
37. Anderton N, Giri A, Wei G, Marcus R, Chen X, Bjordahl T, Habib A, Herrera J and Beddhu S: Sedentary behavior in individuals with diabetic chronic kidney disease and maintenance hemodialysis. J Ren Nutr (2015) 25: 364–370.
38. Hishii S, Miyatake N, Nishi H, Katayama A, Ujike K, Koumoto K, Suzuki H and Hashimoto H: Validity of Sedentary Behavior Evaluation using Questionnaire for Chronic Hemodialysis Patients. Journal of Shikoku Public Health Society (2019) in press (in Japanese).