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ORIGINAL ARTICLE

# Snow Removal Maintains Physical Function in Hemodialysis Patients after One Year: A Pilot Study

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**Objectives:** Physical activity is an important prognostic factor in managing hemodialysis patients. During winter, physical activity decreases, which necessitates interventions to maintain physical function. This study investigated whether snow removal is an effective physical activity to maintain physical function in hemodialysis patients. **Methods:** This retrospective cohort study examined 32 patients (aged 68.9 ± 14.2 years, 21 men) who underwent hemodialysis at Uonuma Kikan Hospital from March 2021 to March 2022. The patients were divided into snow-remover and non-snow-remover groups. The primary outcome was the Short Physical Performance Battery (SPPB). Secondary outcomes were grip strength, skeletal muscle index, and physical activity level. Differences in outcomes between the groups were investigated at 1 year of follow-up. **Results:** The snow-remover group had significantly high SPPB score, grip strength (men), skeletal muscle index (men), and physical activity at baseline. The decline in SPPB after 1 year was significantly smaller in the snow-remover group than in the non-snow-remover group. The level of physical activity in the non-snow-remover group decreased over time. **Conclusions:** Snow removal contributed to the maintenance of physical function in hemodialysis patients after 1 year. However, snow removal is not recommended for all hemodialysis patients, and further studies should identify other safe winter activities to maintain physical function.

**Key Words:** dialysis; short physical performance battery; snow shoveling

## INTRODUCTION

Physical activity is a significant factor that greatly affects prognosis in hemodialysis patients.[1–3] Every 10 min/day of physical activity reduces mortality by 22% in dialysis patients.[4] Physical activity is vital for patient management because hemodialysis patients are less active than individuals with normal kidney function.[5,6] However, hemodialysis patients encounter many difficulties in improving their physical activity because they spend much of their time in regular dialysis sessions.[7]

There are seasonal variations in the duration and type of physical activity, and activity typically decreases during the winter season.[8] Environmental factors such as temperature, rain, and snow may limit the outdoor activities of individuals,[9] and feasible activity decreases during the winter season. Therefore, alternative strategies should be implemented to maintain individuals' physical activity during the winter season.

Snow removal is an essential physical activity of daily life in snowy areas. We showed that hemodialysis patients who remove snow are more physically active in winter than those who do not remove snow.[10] Snow removal may contribute to maintaining the physical function of patients. However, no study to date has elucidated how snow removal affects the physical function of hemodialysis patients in snowy areas.

Therefore, the purpose of this study was to investigate whether snow removal contributes to the maintenance of physical function in hemodialysis patients. This study will provide meaningful information for the management of hemodialysis patients in snowy regions.

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## MATERIALS AND METHODS

### Study Subjects

This retrospective cohort study enrolled 37 participants who underwent maintenance hemodialysis from March 2021 to March 2022 at Uonuma Kikan Hospital, Japan. Residence within the Uonuma area of Niigata Prefecture and at least 3 months of dialysis treatment were used as inclusion criteria. The Uonuma area in Niigata Prefecture is part of one of Japan's prominent snowbelts. In this area, some hemodialysis patients have to remove snow by themselves. The following exclusion criteria were used: unstable arrhythmia (n=0), unstable hypertension (n=0), and unable to walk (n=5). A total of 32 participants were eligible for enrollment in the study. The institutional review board of the Ethics Committee of Uonuma Kikan Hospital approved the study protocol (no. 30-056). Written informed consent could not be obtained because of the constraints imposed by the retrospective design, although participants could withdraw from this study at any time using an opt-out procedure. The study was conducted in accordance with the Declaration of Helsinki and the ethical guidelines for medical and health research involving human subjects.

### Clinical Characteristics

We collected details such as participants' demographic factors (age and sex), body mass index (BMI), primary illness of renal failure, comorbidities, laboratory blood tests (hemoglobin, serum albumin, and C-reactive protein), erythropoiesis stimulating agents, and hemodialysis data from their medical records. Laboratory blood tests were performed before and after the hemodialysis sessions.

### Snow-removal Activity

Based on a previous study,[10] participants were asked whether they remove snow at least once a week in winter. Anyone that answered "Yes" was defined as a "snow remover". Information on the tools, frequency, and time of snow removal was collected through questionnaires.

### Meteorological Data

Meteorological data for the Uonuma area were collected from the Japan Meteorological Agency (http://www.jma.go.jp/jma/index.html). The search period was from December 2021 to February 2022.

### Outcomes

The primary outcome was the Short Physical Performance Battery (SPPB). The SPPB is a valid, reliable, and responsive assessment that comprises the following aspects: standing balance, gait speed over 4 m, and 5 times chair–stand test.[11] Scores ranged from 0 to 12, with higher scores indicating better physical function. The SPPB was assessed based on an earlier study.[12] Secondary outcomes were grip strength, skeletal muscle index (SMI), and physical activity. Grip strength was measured twice in the standing position, and the maximum value was noted. A multifrequency bioelectrical impedance device (InBody S10, Inbody Japan, Tokyo, Japan) was used to estimate muscle mass. The SMI was calculated as follows: SMI=lean muscle mass/height$^2$. The estimated muscle mass was measured within 30 min after dialysis. We used the International Physical Activity Questionnaire (IPAQ)—Short Form to evaluate physical activity, because IPAQ is recognized worldwide for both its reliability and validity.[13] IPAQ is able to summarize the weekly performance of walking activities and other high to moderate-intensity activities. In a previous study, this questionnaire was used to assess physical activity among Japanese hemodialysis patients.[10] Physical activities of high to moderate intensity and walking activity were summed according to an earlier study.[10] Total physical activity was defined as the metabolic equivalent of task (MET) score per week (MET-min/week). The summed duration of moderate- and high-intensity activities was defined as the moderate- to vigorous-intensity physical activity (MVPA). All evaluations were performed using the methods described in our previous study.[10]

Participants were assessed at baseline in March 2021 and were re-evaluated 1 year later (as follow-up) in March 2022. The difference between the follow-up and baseline results was calculated as the amount of change (Δ). The same physical therapist performed all the evaluations.

### Statistical Analysis

Baseline values and the amount of change were compared between the snow-remover and non-snow-remover groups. A chi-squared test was performed to analyze categorical variables, and an unpaired *t*-test was used to analyze continuous variables. All the statistical tests were performed using SPSS version 28.0 (IBM, Tokyo, Japan). P-values less than 0.05 indicated statistical significance.

## RESULTS

### Participant Characteristics

**Figure 1** shows the flowchart of this study. At baseline, 32 maintenance dialysis patients satisfied the study criteria.

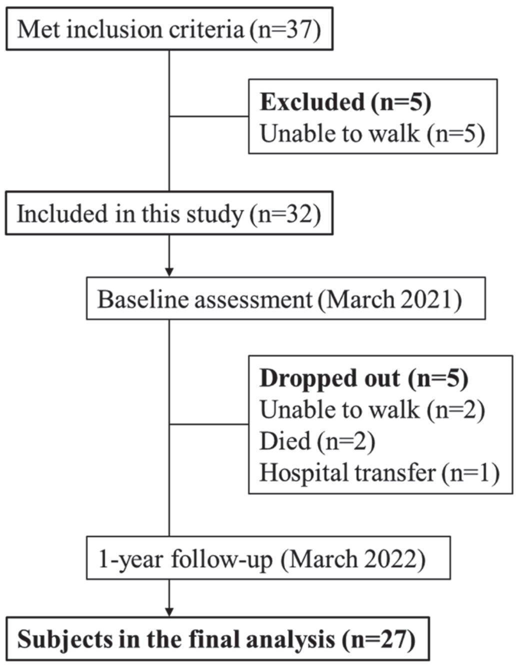


**Fig. 1.** Flowchart for this study.

Among the 32 participants, 12 performed snow removal and 20 were assigned to the non-snow-remover group. During the follow-up period, 5 patients (non-snow-remover group) dropped out; 2 patients were unable to walk, 2 patients died, and 1 patient was transferred to another hospital. Therefore, 27 patients were included in the final evaluation. At the final analysis, 12 patients remained in the snow-remover group, whereas 15 patients remained in the non-snow-remover group. **Table 1** shows the patient characteristics of both groups at baseline. There were no significant differences in age, sex, BMI, primary illness, or dialysis data. The snow-remover group mostly used shovels to remove snow 2–4 days/week for less than 1 h each day. There were no adverse events or accidents related to snow removal during the study period.

### Meteorological Data in Winter

**Table 2** shows meteorological data for the Uonuma area in winter. Snowfall during this period was similar to that of a regular year.

### Baseline Physical Function Parameters

**Table 3** shows the physical function parameters at baseline for the two groups. The SPPB score and physical activity were significantly higher in the snow-remover group than in the non-snow-remover group. Furthermore, grip strength and SMI were significantly higher for men in the snow-remover group.

### Amount of Change in Physical Function Parameters

**Table 4** shows the changes from baseline to follow-up for the physical function parameters for the two groups. At follow-up, SPPB in the snow-remover group was marginally lower (average decline −0.3), whereas SPPB was significantly lower in the non-snow-remover group (average decline −1.9). There was no significant difference in grip strength or SMI between the groups; however, the change in physical activity was significantly different between the two groups.

## DISCUSSION

This retrospective cohort study investigated the effect of snow-removal activity on the physical function of maintenance hemodialysis patients. Results revealed that the snow-remover group preserved their physical function after 1 year of follow-up. To our knowledge, no other study has investigated the effects of snow removal on the physical function of hemodialysis patients. Our study indicates that snow removal is a physical activity that can help preserve physical function in maintenance hemodialysis patients.

Physical function was preserved in the snow-remover group at the one-year follow-up. We previously showed in a cross-sectional study that hemodialysis patients who performed snow-removal activities had higher physical function.[10] However, it was unclear whether snow removal contributed to the maintenance of physical function. The minimal detectable change scores for the 90% confidence intervals in the SPPB of hemodialysis patients were described as 1.7 points.[12] After follow-up, SPPB for the non-snow-remover group decreased by 1.9 points, whereas SPPB for the snow-remover group decreased by 0.3 points. Physical function was preserved in the snow-remover group. Physical activity in the snow-remover group was higher than in the non-snow-remover group at baseline and at follow-up. Higher physical activity is associated with higher physical function in hemodialysis patients.[1,2] Therefore, snow removal contributes to increased physical activity and positively affects physical function. However, baseline grip strength and SPPB were higher in the snow-remover group than in the non-snow-remover group. Having high physical function and an active lifestyle may be considered prerequisites for performing snow removal. In other words, only patients who are capable of snow removal can perform this activity.

**Table 1** . Patient characteristics

| | Total (n=32) | Snow remover (n=12) | Non-snow remover (n=20) | P value |
|---|---|---|---|---|
| Age (years) | 68.9±14.2 | 63.3±16.4 | 72.3±12.0 | 0.086 |
| Men (n) | 21 (65.6) | 9 (75.0) | 12 (60.0) | 0.319 |
| BMI (kg/m$^2$) | 23.3±5.0 | 23.7±2.6 | 23.0±6.0 | 0.711 |
| Primary illness (n) | | | | |
| Diabetic nephropathy | 12 (37.5) | 5 (41.7) | 7 (35.0) | 0.497 |
| Hypertensive nephrosclerosis | 8 (25.0) | 4 (33.3) | 4 (20.0) | 0.332 |
| Chronic glomerulonephritis | 2 (6.3) | 0 (0.0) | 2 (10.0) | 0.258 |
| Other | 7 (21.9) | 2 (16.7) | 5 (25.0) | 0.465 |
| Unknown | 3 (9.4) | 1 (8.3) | 2 (10.0) | 0.690 |
| Dialysis vintage (years) | 8.3±10.0 | 8.2±10.8 | 8.3±9.8 | 0.972 |
| Comorbidities (n) | | | | |
| Hypertension | 22 (68.8) | 7 (58.3) | 15 (75.0) | 0.275 |
| Diabetes mellitus | 12 (37.5) | 7 (58.3) | 5 (25.0) | 0.059 |
| Chronic heart failure | 8 (25.0) | 4 (33.3) | 4 (20.0) | 0.332 |
| Ischemic heart disease | 6 (18.8) | 2 (16.7) | 4 (20.0) | 0.601 |
| Cerebrovascular disease | 2 (6.3) | 0 (0.0) | 2 (10.0) | 0.383 |
| Blood laboratory data | | | | |
| Hemoglobin (mg/dl) | 10.9±1.0 | 11.1±0.8 | 10.8±1.1 | 0.574 |
| Albumin (mg/dl) | 3.5±0.3 | 3.6±0.4 | 3.4±0.3 | 0.045 |
| C-reactive protein (mg/dl) | 0.5±0.8 | 0.3±0.3 | 0.6±0.9 | 0.236 |
| Erythropoiesis stimulating agent | | | | |
| User (n) | 20 (62.5) | 6 (50.0) | 14 (70.0) | 0.258 |
| Dose (µg/week) | 20 [15, 40] | 25 [20, 40] | 20 [10, 40] | 0.329 |
| Dialysis data | | | | |
| Winter | | | | |
| Serum creatinine before dialysis (mg/dl) | 10.0±3.2 | 10.1±4.5 | 9.9±1.8 | 0.222 |
| Serum creatinine after dialysis (mg/dl) | 3.7±1.2 | 3.6±2.2 | 3.7±1.1 | 0.235 |
| eGFR before dialysis (ml/min/1.73m$^2$) | 4.8±1.6 | 4.6±2.8 | 4.9±1.6 | 0.191 |
| eGFR after dialysis (ml/min/1.73m$^2$) | 12.0±4.0 | 12.5±4.4 | 11.7±3.9 | 0.108 |
| Dehydration (ml) | 1857±933 | 1792±851 | 1968±903 | 0.278 |
| Kt/V | 1.3±0.2 | 1.3±0.3 | 1.3±0.2 | 0.592 |
| Non-winter | | | | |
| Serum creatinine before dialysis (mg/dl) | 9.5±3.5 | 9.8±4.7 | 9.3±2.4 | 0.198 |
| Serum creatinine after dialysis (mg/dl) | 3.3±2.1 | 3.5±2.9 | 3.0±1.9 | 0.417 |
| eGFR before dialysis (ml/min/1.73m$^2$) | 5.1±1.9 | 5.3±2.4 | 4.8±1.9 | 0.211 |
| eGFR after dialysis (ml/min/1.73m$^2$) | 11.1±3.7 | 11.5±4.2 | 11.0±3.9 | 0.256 |
| Dehydration (ml) | 1982±967 | 1850±939 | 2055±962 | 0.301 |
| Kt/V | 1.3±0.2 | 1.3±0.3 | 1.3±0.2 | 0.688 |
| Snow removal | | | | |
| Tool (n) | | | | |
| Snow shovel | 12 (100.0) | 12 (100.0) | | |
| Snow blower | 1 (8.3) | 1 (8.3) | | |
| Frequency (n) | | | | |
| 1 day/week | 2 (16.6) | 2 (16.6) | | |
| 2–4 days/week | 10 (83.3) | 10 (83.3) | | |
| 5–7 days/week | 0 (0.0) | 0 (0.0) | | |
| Time (n) | | | | |
| Up to 1 h | 12 (100.0) | 12 (100.0) | | |
| More than 1 h | 0 (0.0) | 0 (0.0) | | |

Values are means (standard deviation), median [25th percentile, 75th percentile], or number of subjects (n) with percentages in parentheses.
eGFR, estimated Glomerular Filtration Rate.
The erythropoiesis stimulating agent was Darbepoetin alfa.

**Table 2.** Meteorological data for the Uonuma area in winter

| Average temperature (°C) | Average precipitation (mm) | Average wind velocity (m/s) | Cumulative snowfall (cm) |
|---|---|---|---|
| 0.5±1.2 | 8.5±2.6 | 1.9±0.3 | 340.7±44.7 |

Values are means ± standard deviation.
Data is the average from December 2021 to February 2022.

**Table 3.** Comparison of baseline physical function and activity between snow-remover and non-snow-remover groups

| | Total (n=32) | Snow remover (n=12) | Non-snow remover (n=20) | P value |
|---|---|---|---|---|
| Physical function | | | | |
| SPPB | 12 [8, 12] | 12 [12, 12] | 9 [7, 12] | <0.001 |
| Balance test | 4 [2, 4] | 4 [4, 4] | 3 [2, 4] | <0.001 |
| Gait speed test | 4 [4, 4] | 4 [4, 4] | 4 [2, 4] | 0.007 |
| Chair–stand test | 4 [2, 4] | 4 [4, 4] | 3 [2, 4] | <0.001 |
| Grip strength (kg) | | | | |
| Men | 26.0±9.2 | 32.2±9.3 | 21.4±6.1 | 0.004 |
| Women | 20.4±5.5 | 24.4±4.6 | 18.9±5.3 | 0.152 |
| SMI (kg/m$^2$) | | | | |
| Men | 6.4±0.9 | 7.1±0.7 | 6.0±0.8 | 0.007 |
| Women | 6.0±1.2 | 6.5±0.2 | 5.8±1.4 | 0.297 |
| Physical activity | | | | |
| Total activity (MET-min/week) | 942.4±768.5 | 1312.3±661.8 | 720.6±756.1 | 0.033 |
| MVPA (MET-min/week) | 338.1±398.0 | 545.0±415.3 | 214.0±339.7 | 0.020 |

Values are means ± standard deviation or median [25th percentile, 75th percentile].

**Table 4.** Comparison of changes in physical function and activity between snow-remover and non-snow-remover groups after follow-up

| | Total (n=27) | Snow remover (n=12) | Non-snow remover (n=15) | P value |
|---|---|---|---|---|
| Physical function | | | | |
| SPPB | −1 [−2, 0] | 0 [0, 0] | −2 [−4, −1] | 0.010 |
| Balance test | 0 [−1, 0] | 0 [0, 0] | 0 [−1, 0] | 0.079 |
| Gait speed test | 0 [−1, 0] | 0 [0, 0] | 0 [−1, 0] | 0.415 |
| Chair–stand test | 0 [−1, 0] | 0 [0, 0] | −1 [−2, 0] | 0.006 |
| Grip strength (kg) | 0.3±3.2 | 1.4±2.3 | −0.7±3.6 | 0.090 |
| SMI (kg/m$^2$) | 0.2±1.4 | 0.5±2.1 | −0.1±0.4 | 0.296 |
| Physical activity | | | | |
| Total activity (MET-min/week) | −59.4±359.9 | 96.9±320.1 | −184.5±349.8 | 0.041 |
| MVPA (MET-min/week) | −39.3±211.8 | 35.0±113.5 | −98.7±254.3 | 0.010 |

Data calculated as follow-up minus baseline; values are mean ± standard deviation or median [25th percentile, 75th percentile].

Physical activity tends to decrease in winter compared to summer. This is because environmental factors such as low temperatures and the presence of snow inhibit outdoor activity in winter.[9,14] When outdoor activity is limited, activities at gyms or recreational facilities help to maintain physical function. However, access to such facilities is more difficult in rural areas than in urban areas and, in many cases, barriers to physical activity exist. Therefore, snow removal is a convenient and accessible activity that can be done at home.

However, snow-removal activities can also be dangerous.

Earlier studies report the occurrence of accidents during snow removal.[15,16] Snow removal is a high-intensity activity[17] in a cold environment that may evoke cardiac events.[18] Hemodialysis patients comprise a frailer population than the general population.[19,20] A risk of fall and fracture is another big issue for hemodialysis patients who have poor physical function and bone quality. Snow removal is a potentially dangerous activity for individuals with poor physical function. Therefore, it may suit some patients to improve their physical function before the winter season by performing intradialytic exercise. In other words, this study's results do not recommend that all dialysis patients perform snow-removal activities. Some areas provide snow removal as a government service, and such services should remain available. Healthcare providers should assess the patient's physical function and suggest appropriate snow removal methods. Hemodialysis patients have time constraints because they have dialysis three times a week. Therefore, we believe that accessible physical activity is suitable for hemodialysis patients, regardless of snowfall or its removal. In areas where heavy snowfalls occur, snow removal should be considered as a physical activity for hemodialysis patients,[10] whereas other activities, like gardening and farming around the home, should be considered in areas without snowfall.

This study has several limitations. First, this study was a pilot study; hence, it considered a small sample size and involved limited statistical analysis. Confounding factors affecting outcomes such as age and nutritional status could not be excluded. We calculated that at least 118 participants should be considered for multivariate analysis. We suggest that future studies should adjust for the baseline physical function and examine the "snow removal × time" interaction. Second, this study did not accurately measure the frequency, days, hours, and area of snow removal, so it was not possible to objectively show the amount of physical activity involved in snow removal. Similarly, in this study, physical activity assessment was performed using a questionnaire. Acquisition of objective data through the use of accelerometers would be preferable. Third, we did not examine patients' physical activity in non-winter seasons. In the Uonuma area, many patients are involved in agricultural work or other activities from spring to fall.[21] Hence, the impact of agricultural work, in addition to snow removal, should be considered. To exclude the influence of physical activities other than snow removal, assessments need to be carried out several times outside of winter. Future studies need to design multicenter studies that include quantitative physical activity assessments.

## CONCLUSION

Snow-removal activity contributes to the preservation of physical function in maintenance hemodialysis patients. In areas with heavy snowfall and limited access to the outdoors, snow removal may be an effective physical activity. However, it is not recommended for all hemodialysis patients because it is a high-intensity exercise and involves some risks. Future research should identify winter activities that are safer than snow removal for dialysis patients.

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## CONFLICTS OF INTEREST

All the authors have declared no competing interest.

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