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

There are seasonal variations in the duration and type of physical activity, and activity typically decreases during the winter season. Environmental factors such as temperature, rain, and snow may limit the outdoor activities of individuals, 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. 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.

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.
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/height². The estimated muscle mass was measured within 30 min after dialysis.

RESULTS

Participant Characteristics
Figure 1 shows the flowchart of this study. At baseline, 32 maintenance dialysis patients satisfied the study criteria.
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. 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. 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. 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/m²)                  | 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/1.73m²) | 4.8±1.6 | 4.6±2.8 | 4.9±1.6 | 0.191 |
| eGFR after dialysis (ml/min/1.73m²) | 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/1.73m²) | 5.1±1.9 | 5.3±2.4 | 4.8±1.9 | 0.211 |
| eGFR after dialysis (ml/min/1.73m²) | 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)          | Total (n=32) | Snow remover (n=12) | Non-snow remover (n=20) |
|-------------------|-------------|---------------------|-------------------------|
| 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.
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. 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.

### 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/m²)     |              |                     |                         |         |
| 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) |            |                     |                         |         |
| Men             | 0.3±3.2      | 1.4±2.3             | −0.7±3.6                | 0.090   |
| Women           | 0.2±1.4      | 0.5±2.1             | −0.1±0.4                | 0.296   |
| SMI (kg/m²)     |              |                     |                         |         |
| Men             | −59.4±359.9  | 96.9±320.1          | −184.5±349.8            | 0.041   |
| Women           | −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].
Earlier studies report the occurrence of accidents during snow removal.\textsuperscript{15,16} Snow removal is a high-intensity activity\textsuperscript{17} in a cold environment that may evoke cardiac events.\textsuperscript{18} Hemodialysis patients comprise a frailer population than the general population.\textsuperscript{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,\textsuperscript{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.\textsuperscript{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.

**ACKNOWLEDGMENTS**

We thank the staff of the hemodialysis center of Uonuma Kikan Hospital for their support toward this study.

**CONFLICTS OF INTEREST**

All the authors have declared no competing interest.

**REFERENCES**

1. Tarca BD, Wycherley TP, Bennett P, Meade A, Ferrar KE: Modifiable physical factors associated with physical functioning for patients receiving dialysis: a systematic review. J Phys Act Health 2020;17:475–489. https://doi.org/10.1123/jpah.2019-0338, PMID:32045878
2. Nawab KA, Storey BC, Staplin N, Walmsley R, Haynes R, Sutherland S, Crosbie S, Pugh CW, Harper CH, Landray MJ, Doherty A, Herrington WG: Accelerometer-meaured physical activity and functional behaviours among people on dialysis. Clin Kidney J 2021;14:950–958. https://doi.org/10.1093/ckj/sfaa045, PMID:33777379
3. Yamamoto S, Matsuzawa R, Hoshi K, Harada M, Watanabe T, Suzuki Y, Isobe Y, Imamura K, Osada S, Yoshida A, Kamiya K, Matsunaga A: Impact of physical activity on dialysis and nondialysis days and clinical outcomes among patients on hemodialysis. J Ren Nutr 2021;31:380–388. https://doi.org/10.1053/j.jrn.2020.07.007, PMID:32357227
4. Matsuzawa R, Matsunaga A, Wang G, Kutsuna T, Ishii A, Abe Y, Takagi Y, Yoshida A, Takahira N: Habitual physical activity measured by accelerometer and survival in maintenance hemodialysis patients. Clin J Am Soc Nephrol 2012;7:2010–2016. https://doi.org/10.2215/CJN.03660412, PMID:22977216
5. Johansen KL, Chertow GM, Ng AV, Mulligan K, Carey S, Schoenfeld PY, Kent-Braun JA: Physical activity levels in patients on hemodialysis and healthy sedentary controls. Kidney Int 2000;57:2564–2570. https://doi.org/10.1046/j.1523-1755.2000.00116.x, PMID:10844626

6. Zamojska S, Szkłarek M, Niewodniczy M, Nowicki M: Correlates of habitual physical activity in chronic haemodialysis patients. Nephrol Dial Transplant 2006;21:1323–1327. https://doi.org/10.1093/ndt/gfi323, PMID:16421165

7. Matsuzawa R, Roshanravan B, Shimoda T, Mamorita N, Yoneki K, Harada M, Watanabe T, Yoshida A, Takeuchi Y, Matsunaga A: Physical activity dose for hemodialysis patients: where to begin? Results from a prospective cohort study. J Ren Nutr 2018;28:12–16. https://doi.org/10.1053/j.jrn.2017.07.004, PMID:2893466

8. Ogawa S, Seko T, Ito T, Mori M: Differences in physical activity between seasons with and without snowfall among elderly individuals residing in areas that receive snowfall. J Phys Ther Sci 2019;31:12–16. https://doi.org/10.1589/jpts.31.12, PMID:30774197

9. Klompstra L, Jaarsma T, Strömberg A, van der Wal MH: Seasonal variation in physical activity in patients with heart failure. Heart Lung 2019;48:381–385. https://doi.org/10.1016/j.hrthlm.2019.04.003, PMID:31122692

10. Sato Y, Iino N: Snow removal maintained a high level of physical activity in patients undergoing hemodialysis in heavy snowfall areas. Ren Replacement Ther 2021;7:11–17. https://doi.org/10.1186/s41100-021-00330-2

11. Freiberger E, de Vreede P, Schoene D, Rydwik E, Mueller V, Frändin K, Hopman-Rock M: Performance-based physical function in older community-dwelling persons: a systematic review of instruments. Age Ageing 2012;41:712–721. https://doi.org/10.1093/ageing/afs099, PMID:22885845

12. Ortega-Pérez de Villar L, Martinez-Olmos FJ, Junqué-Jiménez A, Amer-Cuenca JJ, Martinez-Gramaje J, Mercer T, Segura-Orti E: Test–retest reliability and minimal detectable change scores for the short physical performance battery, one-legged standing test and timed up and go test in patients undergoing hemodialysis. PLoS One 2018;13:e0201035. https://doi.org/10.1371/journal.pone.0201035, PMID:30133445

13. Craig CL, Marshall AL, Sjöström M, Bauman AE, Booth ML, Ainsworth BE, Pratt M, Ekelund U, Yngve A, Sallis JF, Oja P: International physical activity questionnaire: 12-country reliability and validity. Med Sci Sports Exerc 2003;35:1381–1395. https://doi.org/10.1249/01.MSS.0000078924.61453.FB, PMID:12900694

14. Hasegawa J, Suzuki H, Yamauchi T: Impact of season on the association between muscle strength/volume and physical activity among community-dwelling elderly people living in snowy-cold regions. J Physiol Anthropol 2018;37:25–30. https://doi.org/10.1186/s40101-018-0186-6, PMID:30424801

15. Yamaguchi S, Endoh H, Nitta M: Accidental falls related to clearing heavy snow on rooftops in a rural heavy snow area in Japan. Acute Med Surg 2017;4:166–171. https://doi.org/10.1002/ams2.246, PMID:29123856

16. Hatakeyama Y, Miyakoshi N, Ishikawa N, Tazawa H, Yumoto S, Tomite T, Shoji R, Shimada Y: Falls from heights while clearing snow in Akita prefecture: reevaluation after preventive countermeasures and public service. J Orthop Sci 2020;25:503–506. https://doi.org/10.1016/j.jos.2019.05.004, PMID:31174966

17. Smolander J, Louhevaara V, Ahonen E, Polari J, Klen T: Energy expenditure and clearing snow: a comparison of shovel and snow pusher. Ergonomics 1995;38:749–753. https://doi.org/10.1080/00140139508925146, PMID:7729401

18. Franklin BA, George P, Henry R, Gordon S, Timmis GC, O’Neill WW: Acute myocardial infarction after manual or automated snow removal. Am J Cardiol 2001;87:1282–1283. https://doi.org/10.1016/S0002-9149(01)01520-X, PMID:11377355

19. Kojima G, Iliffe S, Taniguchi Y, Shimada H, Rakugi H, Walters K: Prevalence of frailty in Japan: a systematic review and meta-analysis. J Epidemiol 2017;27:347–353. https://doi.org/10.1016/j.je.2016.09.008, PMID:28142044

20. Johanssen KL, Chertow GM, Jin C, Kutner NG: Significance of frailty among dialysis patients. J Am Soc Nephrol 2007;18:2960–2967. https://doi.org/10.1681/ASN.2007020221, PMID:17942958

21. Kabasawa K, Tanaka J, Nakamura K, Ito Y, Yoshida K, Takachi R, Sawada N, Tsugane S, Narita I: Study design and baseline profiles of participants in the Uonuma CKD cohort study in Niigata, Japan. J Epidemiol 2020;30:170–176. https://doi.org/10.2188/jea.JE20180220, PMID:30956257