Assignment of Registered Dietitians and Other Healthcare Professionals Positively Affects Weight Change of Underweight Patients in Convalescent (*Kaifukuki*) Rehabilitation Wards: A Secondary Analysis of a Nationwide Survey

Shinta NISHIOKA^{1,2}, Yoji KOKURA^{1,3}, Takatsugu OKAMOTO^{4,5},
Masako TAKAYAMA^{1,6} and Ichiro MIYAI^{4,7}

¹Nutrition Committee, Kaifukuki Rehabilitation Ward Association, Tokyo 101-0047, Japan

²Department of Clinical Nutrition and Food Services, Nagasaki Rehabilitation Hospital,
Nagasaki 850-0854, Japan

³Department of Clinical Nutrition, Keiju Medical Center, Ishikawa 926-8605, Japan

⁴Annual Survey Committee, Kaifukuki Rehabilitation Ward Association, Tokyo 101-0047, Japan

⁵Nishi-Hiroshima Rehabilitation Hospital, Hiroshima 731-5143, Japan

⁶Department of Nutrition, Kumamoto Kinoh Hospital, Kumamoto 860-8518, Japan

⁷Morinomiyu Hospital, Osaka 536-0025, Japan

(Received April 10, 2019)

Summary This study aimed to verify the relationship between assignment of professional registered dietitians (RDs) and other healthcare professionals and body weight or functional outcome in underweight patients. This was a secondary analysis of the nation-wide survey data from Kaifukuki (convalescent) rehabilitation wards (KRWs). Data of patients aged ≥ 20 y with disabilities and body mass index (BMI) < 18.5 kg/m² and who were discharged from 1,099 KRWs were analyzed. The primary outcome was BMI at discharge. Secondary outcomes were Functional Independence Measure (FIM) at discharge and returning to home. Patients were divided into two groups: those in KRWs with ≥ 1 or < 1 dedicated RD per ward (KRW/RD+ and KRW/RD–, respectively). Of 5,843 eligible participants (female, 63%; median age, 82 y; hip/vertebral/knee fracture, 47%; stroke, 34%; disuse syndrome secondary to acute illness, 11%; others, 8%), 1,288 and 4,555 were from the KRW/RD+ and KRW/RD– groups, respectively. At discharge, KRW/RD+ patients had higher FIM (93 vs. 90) and BMI (17.1 vs. 17.0 kg/m²) than did KRW/RD– patients. Multivariable analysis showed that assignment of dedicated RDs ($B=0.213$, 95% confidence interval [CI], 0.036–0.389), number of nurses ($B=0.023$, 95% CI, 0.003–0.043), and daily rehabilitation dose were significantly associated with changes in body weight. Furthermore, these factors positively affected BMI at discharge. Number of nurses and rehabilitation dose correlated with FIM, but assignment of RDs did not correlate with FIM. In conclusion, assignment of RDs, nurses, and sufficient rehabilitation dose may contribute to BMI gain. Nurses and daily rehabilitation dose may positively affect functional recovery.

Key Words body mass index, rehabilitation, malnutrition, activities of daily living, discharge destination

Malnutrition occurs frequently in rehabilitation patients, with a prevalence of about 20–45% (1–3). Malnutrition in rehabilitation patients may result in poor functional outcome, including poor swallowing function (1–6); therefore, nutritional care in inpatients in the rehabilitation setting has become a crucial matter. Of note, weight loss prevention may be the predominant target of nutritional care, as this improves activities of daily living (ADL) among rehabilitation patients (7, 8).

Nutritional care professionals such as registered dietitians (RDs) play a key role in performing appropriate nutritional assessment, planning and recommending nutritional care, and nutritional monitoring and evaluation in inpatient rehabilitation facilities or units (9).

Several studies have shown that RD nutritional recommendations or privileges concerning order-writing by RDs may increase energy intake or decrease erroneous orders (10, 11). Similarly, a pilot study demonstrated that nutritional monitoring performed by a RD at least once a week positively impacts on maintenance of body weight in underweight patients after stroke, compared to monitoring just once a month (12).

Given the expected effectiveness of RD intervention on nutritional outcome, some countries have established nutritional care regulations in inpatient rehabilitation settings. In the US, nutritional status of patients in inpatient rehabilitation facilities must be assessed by day 3 of admission; in addition, some nutritional problems such as morbid obesity are listed on the requirement of inpatient rehabilitation facilities for Medicare

E-mail: shintacks@yahoo.co.jp

payment (9). Beginning in April 2018, for the full National Health Insurance reimbursement of admission fees at Kaifukuki (convalescent) Rehabilitation Wards (KRWs) in Japan, nutritional assessment must be performed and documented in rehabilitation planning with participation of dedicated RDs, and patients at risk of malnutrition are to be monitored for their nutritional status at least once a week (<https://www.mhlw.go.jp/stf/seisakunitsuite/bunya/0000188411.html>). However, the effectiveness of assigning a dedicated RD on nutritional or functional outcome in the inpatient rehabilitation setting has never been validated. Thus, there is a need to verify the effectiveness of assigning a dedicated RD; however, since the assignment of RDs may be closely linked to other circumstantial factors such as the number of beds and number of other healthcare professionals, these confounders should be considered. If the impact effect of assigning of healthcare professionals on nutritional outcome is verified, it will provide evidence that an appropriate nutrition care system is established in inpatients rehabilitation hospitals or facilities where assigning them. Accordingly, this study aimed to verify the relationship between RDs and other healthcare professionals' assignment and body weight in underweight patients in KRWs based on a nationwide survey that had a high response rate.

MATERIALS AND METHODS

In this retrospective study, data from the 2016 annual survey of KRWs were analyzed to compare staff distribution, including RD, and body weight change of underweight adult rehabilitation inpatients. The primary outcome of this study was change in body mass index (BMI) at discharge; the secondary outcomes were Functional Independence Measure (FIM) at discharge and home discharge rate. This study has been performed in accordance with the ethical standards established in the 1964 Declaration of Helsinki and later amendments. Since the survey data were completely anonymized, this study was exempt by the institutional review board of Nagasaki Rehabilitation Hospital (No. NRH-0001), and no individual patient consent was required.

Kaifukuki rehabilitation wards. KRWs comprise a unique system for providing inpatient rehabilitation in Japan (13). Patients, after specific disease, injuries, or surgery (e.g., stroke, traumatic head injury, hip fracture) are offered admission to KRWs for 60 (for injuries to the nerve, muscle, ligament of femur, pelvis, spine, and knee) to 180 (for stroke or other cerebrovascular diseases with a higher degree of brain dysfunction) days, depending on the primary disease condition. Public health care insurance covers the hospital fee at KRWs, including individualized rehabilitation programs and standard nutritional care via the hospital diet or enteral/parenteral nutrition. A multidisciplinary rehabilitation team provides a comprehensive rehabilitation program and consists of medical doctors, nurses, physical therapists (PT), occupational therapists (OT), speech-hearing-language therapists (ST), social workers, care workers, RDs, and pharmacists. The standard rehabilitation programs

provided by dedicated PT, OT, and ST are classified into three categories: rehabilitation for cerebrovascular and cerebral diseases (e.g., stroke, traumatic brain injury), including therapeutic exercise, gait and balance training, task-oriented training in ADL, speech and swallowing therapy, and cognitive rehabilitation; rehabilitation for orthopedic diseases (e.g., hip fracture, vertebral compression fracture), including therapeutic exercise, range of motion exercise, muscle strengthening exercise, gait and balance training, and task-oriented training in ADL; and rehabilitation for disuse syndrome (e.g., owing to surgical procedure or pneumonia) similar to that for orthopedic diseases. In 2016, 1,729 KRWs (in 1,363 hospitals) existed in Japan.

Annual survey. The annual survey, conducted between August and October each year, was started in 2002 by the KRW Association. The KRW Association consists of 79.5% of all hospitals with KRWs in Japan. The collected information comprises four different components: 1) hospital-related information (e.g., hospital entity, number of beds, number of healthcare staff, and equipment); 2) ward-related information (e.g., number of KRW beds, number of healthcare staff working at the KRW, and equipment); 3) patient-related information including patients' characteristics (e.g., age, sex, primary disease for which rehabilitation was required, and date of disease onset/admission/discharge), ADL (FIM at admission and discharge), discharge destination (e.g., home, long-term care facilities, acute care hospitals, long-term care hospitals, and death), and anthropometric data (height and body weight at admission and discharge); and 4) free answers. Anonymized data of consecutive patients who were discharged from each KRW between August and September were collected annually during each survey. Each facility was encouraged to use the survey form constructed in an Excel file, available on the KRW Association's website. Captured or handwritten data were sent via e-mail or facsimile for analysis. Of all KRWs in Japan, 1,099 KRWs (63.6% of all KRWs in Japan) from 823 hospitals responded to the survey. Data were obtained in an anonymized manner in compliance with the Act on Personal Information Protection Law and Clinical Trials Act.

Under the ward-related information, the numbers of the following healthcare staffs working in the KRW were collected during the survey: medical doctors, nurses, physical therapists, occupational therapists, speech therapists, social workers, and RDs. Regarding RDs, only those performing the role of clinical nutrition practitioners at the KRW were reported in the survey. In general, RDs as clinical nutrition practitioners in KRW perform following (http://www.rehabili.jp/active_data/kanri-eiyoushi-hikei_img.pdf): nutritional screening; nutritional assessment; planning and recommendation of nutrition care; nutrition monitoring and re-assessment; nutritional counseling and education; participation in rehabilitation conference; adjustment of discharge nutrition care plan; and writing nutrition care summary. Dietitians with other roles (e.g., hospital food management or clinical nutrition practice for wards

Table 1. Demographic data of the 5,843 underweight patients in the convalescent (*Kaifukuki*) rehabilitation wards.

	Missing	Overall	KRW with RD	KRW without RD	p-value
Number of individuals		5,843	1,288	4,555	
Age, y ¹	0	82 (74–88)	81 (73–87)	83 (74–88)	0.001
Female, N (%)	0	3,702 (63.4)	777 (60.3)	2,925 (64.2)	0.011
Onset-admission duration, d ¹	638	25 (16–37)	25 (17–36)	25 (15–37)	0.329
Reason for admission, N (%)	0				
Stroke with HBD		816 (14.0)	199 (15.5)	617 (13.5)	0.060
Stroke without HBD		1,163 (19.9)	269 (20.9)	894 (19.6)	
Other neurological disease/injuries with HBD		73 (1.2)	14 (1.1)	59 (1.3)	
Other neurological disease/injuries without HBD		306 (5.2)	81 (6.3)	225 (4.9)	
Hip, vertebral or knee fractures		2,739 (46.9)	565 (43.9)	2,174 (47.7)	
Hospital associated deconditioning		611 (10.5)	138 (10.7)	473 (10.4)	
Injury of nerve, muscle, ligament of hip, vertebra, or knee		29 (0.5)	6 (0.5)	23 (0.5)	
Hip or knee arthroplasty		106 (1.8)	16 (1.2)	90 (2.0)	
FIM-total on admission ¹	0	62 (39–84)	63 (39.3–84)	61 (38–83)	0.244
Daily rehabilitation dose, min/d ¹	167	125 (96–155)	136 (109–159)	122 (91–153)	<0.001
Height on admission, m ^{2 1}	0	153 (147.5–161)	154 (148–162)	153 (147–161)	0.038
Body weight on admission, kg ¹	0	39.5 (35.7–44.0)	40.0 (35.9–44.4)	39.4 (35.7–43.9)	0.085
BMI on admission, kg/m ^{2 1}	0	17.0 (15.9–17.8)	17.0 (16.0–17.8)	17.0 (15.9–17.8)	0.756

KRW, *Kaifukuki* rehabilitation wards; RD, registered dietitian; HBD, higher brain dysfunction (e.g., disturbance of attention or memory, aphasia, apraxia); FIM, Functional Independent Measure; BMI, body mass index.

¹ Expressed as median (interquartile range).

other than the KRW at the hospitals) were not included in the form.

FIM is a globally accepted ADL measurement (14) and consists of 13 motor domains (e.g., eating, bathing, transfer from bed to chair) and 8 cognitive domains (e.g., comprehension, expression, memory). The scores for each domain range from 1 (dependent) to 7 (totally independent). A higher FIM score indicates higher ADL. The requirement for rehabilitation based on primary diseases or other conditions is regulated by the National Healthcare Insurance policy of Japan. BMI was calculated as body weight (kg)/height (m)².

Inclusion and exclusion criteria. This study included the data of patients with BMI <18.5 kg/m² and aged ≥20 y old. Data were excluded if 1) they were missing data for age, sex, primary disease, length of stay, number of RDs, FIM, discharge destination, and BMI; 2) the patient was discharged to an acute care hospital or other rehabilitation hospital or died during hospital stay; or 3) length of stay exceeded the limit of the National Healthcare Insurance policy (60 to 180 d, depending on the primary disease).

Statistical analysis. SPSS statistics version 21 was used for statistical analysis (IBM Japan, Ltd). Normally distributed data were expressed as mean ± standard deviation, while skewed data were described as median and interquartile range (IQR). The Kolmogorov-Smirnov test was performed to assess normality.

The patients were divided into two groups based on the number of RDs at the time of admission to the KRWs: ≥1/ward (KRW with RD) and <1/ward (KRW

without RD). To confirm the potential risk of selection bias, patients' characteristics were compared between the eligible and the excluded. Univariate analysis was performed using unpaired *t*-test, Mann-Whitney's *U*-test, and chi-squared test to compare the characteristics of the wards (e.g., number of beds and healthcare professionals such as medical doctors, nurses, and rehabilitation therapists) and the patients, between KRW with or without RD. The multivariable analysis was implemented using the linear regression analysis for change in body weight, BMI, and FIM and binary logistic regression analysis was used for home discharge. Additionally, subgroup analysis based on the primary disease or conditions was performed for the following categories; stroke, other cerebrovascular diseases, fragile fractures, hospital-associated deconditioning, and others. Confounders that showed significant difference between the groups at the univariate analysis and the potentially influencing factors such as BMI and FIM on admission were included in the multivariable analysis. The number of rehabilitation therapists and the daily rehabilitation dose (min/d) were not included in the multivariable analysis simultaneously because these were closely related. A *p*-value <0.05 was considered as statistically significant. Adjustment for multiple comparisons relied on Bonferroni correction.

RESULTS

Of 1,099 respondent KRWs, 1,058 KRWs provided a response for the number of dedicated RDs. Of these, 227 KRWs had ≥1 RD/ward (KRW with RD), while 831

Table 2. Outcome measures of the 5,843 underweight patients in the convalescent (*Kaifukuki*) rehabilitation wards.

	Missing	Overall	KRW with RD	KRW without RD	<i>p</i> -value
Number of individuals		5,843	1,288	4,555	
FIM-total at discharge ¹	0	90 (57–111)	93 (59–112)	90 (56–111)	0.018
Length of stay, days ¹	0	72 (45–89)	71 (45–90)	72 (45–89)	0.614
Discharge disposition, <i>N</i> (%)	0				
Home		3,627 (62)	822 (64)	2,805 (62)	0.339
Long-term care		1,505 (26)	318 (25)	1,187 (26)	
Acute care		711 (12)	148 (11)	563 (12)	
Body weight at discharge, kg ¹	0	39.8 (35.7–44.5)	40.1 (36.0–45.1)	39.5 (35.6–44.3)	0.002
Body weight change, kg ¹	0	0.0 (–0.9–1.5)	0.3 (–0.7–1.8)	0.0 (–1.0–1.4)	<0.001
BMI at discharge, kg/m ² ¹	0	17.1 (15.9–18.0)	17.1 (16.0–18.1)	17.0 (15.8–18.0)	0.009
BMI change, kg/m ² ¹	0	0.0 (–0.4–0.6)	0.1 (–0.3–0.8)	0.0 (–0.4–0.6)	<0.001

KRW, *Kaifukuki* rehabilitation wards; RD, registered dietitian; FIM, Functional Independent Measure; BMI, body mass index.

¹ Expressed as median (interquartile range).

Table 3. Multiple regression analysis for change in body weight at discharge adjusting for number of healthcare staff and characteristics of 5,549 rehabilitation patients.^{1,2}

Variables	β	<i>B</i>	95% CI of <i>B</i>		<i>p</i> -value
			Lower	Upper	
(Constant)	—	6.944	5.762	8.126	<0.001
Age	–0.125	–0.029	–0.035	–0.022	<0.001
Female	–0.036	–0.205	–0.358	–0.053	0.008
Length of KRW stay	0.054	0.004	0.002	0.006	<0.001
FIM at admission	0.046	0.005	0.002	0.007	0.002
BMI at admission	–0.153	–0.312	–0.365	–0.259	<0.001
Number of KRW beds	–0.006	–0.002	–0.012	0.008	0.723
Daily rehabilitation dose (min/d)	0.046	0.003	0.001	0.005	0.001
Number of healthcare staff					
Medical doctor	–0.010	–0.010	–0.035	0.010	0.448
Nurse	0.039	0.023	0.003	0.043	0.024
Registered dietitian (≥ 1 /ward)	0.032	0.213	0.036	0.389	0.018

BMI, body mass index; β , standardized partial regression coefficient; *B*, partial regression coefficient; CI, confidence interval; KRW, *Kaifukuki* (convalescent) rehabilitation ward; FIM, Functional Independence Measure.

¹ Overall, 294 data of patients were excluded for the analysis due to missing value, ² $R^2=0.051$.

KRWs had <1 RD/ward (KRW without RD). KRW with RD showed a higher number of KRW beds (median 49 beds vs. 46 beds, $p<0.001$), number of nurses (median 20 vs. 18, $p<0.001$), occupational therapists (median 10 vs. 9, $p<0.001$), and speech therapists (median 4 vs. 3, $p<0.001$), whereas KRW with RD showed a lower number of medical doctors (median 3 vs. 4, $p=0.005$). The number of physical therapists did not differ between the groups (median 15 vs. 14, $p=0.266$). Subsequently, based on inclusion criteria, the data for 7,578 patients were reported from 1,058 KRWs. Of these, 1,021 records of patients were excluded due to missing data, 244 were excluded due to prolonged hospital stay, and 470 were excluded due to unplanned discharge. Therefore, the data for 5,843 patients were included in the final analysis. Eligible patients showed longer length of stay (median 72 vs. 62, $p<0.001$), higher admission BMI (median 17.0 vs. 16.9 kg/m², $p<0.001$), and

admission FIM (median 62 vs. 53, $p<0.001$) compared to that of excluded patients. However, no differences were found in assignment of RDs ($p=0.176$), number of medical doctors ($p=0.507$), nurses ($p=0.281$), and rehabilitation therapists ($p=0.384$).

Table 1 indicates the characteristics of the 5,843 patients whose data were extracted from 1,058 KRWs. Among these, 1,288 were extracted from KRW with RD and 4,555 from KRW without RD. The patients in KRW with RD exhibited a younger age ($p=0.001$), female proportion ($p=0.011$), and longer time of rehabilitation therapy ($p<0.001$). On the other hand, no differences were found in primary disease/conditions, FIM, or BMI at admission.

Table 2 shows the outcome measures of the patients. At discharge, patients in KRW with RD had higher FIM, body weight, and BMI ($p=0.018$, $p=0.002$, and $p=0.009$, respectively). Similarly, patients in KRW

Table 4. Multiple regression analysis for the BMI at discharge adjusting for number of healthcare staff and characteristics of 5,549 rehabilitation patients.^{1,2}

Variables	β	<i>B</i>	95% CI of <i>B</i>		<i>p</i> -value
			Lower	Upper	
(Constant)	—	2.648	2.172	3.125	< 0.001
Age	−0.075	−0.010	−0.013	−0.008	< 0.001
Female	−0.014	−0.049	−0.110	0.013	0.119
Length of KRW stay	0.037	0.002	0.001	0.002	< 0.001
FIM at admission	0.030	0.002	0.001	0.003	0.003
BMI at admission	0.725	0.874	0.853	0.895	< 0.001
Number of KRW beds	−0.004	−0.001	−0.005	0.003	0.712
Daily rehabilitation dose (min/d)	0.031	0.001	0.001	0.002	0.001
Number of healthcare staff					
Medical doctor	−0.009	−0.005	−0.015	0.005	0.317
Nurse	0.027	0.009	0.001	0.017	0.022
Registered dietitian (≥ 1 /ward)	0.024	0.095	0.023	0.166	0.009

BMI, body mass index; β , standardized partial regression coefficient; *B*, partial regression coefficient; CI, confidence interval; KRW, Kaifukuki (convalescent) rehabilitation ward; FIM, Functional Independence Measure.

¹ Overall, 294 data of patients were excluded for the analysis due to missing value, ² $R^2=0.558$.

Table 5. Multiple regression analysis for FIM at discharge, with adjustment for the number of healthcare staff and characteristics of 5,549 rehabilitation patients.^{1,2}

Variables	β	<i>B</i>	95% CI of <i>B</i>		<i>p</i> -value
			Lower	Upper	
(Constant)	—	−7.817	−15.049	−0.584	0.034
Age	−0.009	−0.025	−0.063	0.014	0.218
Female sex	0.026	1.760	0.826	2.693	< 0.001
Length of KRW stay	0.112	0.097	0.084	0.109	< 0.001
FIM at admission	0.881	1.028	1.011	1.046	< 0.001
BMI at admission	0.021	0.514	0.190	0.838	0.002
Number of KRW beds	−0.008	−0.030	−0.093	0.034	0.361
Daily rehabilitation dose (min/d)	0.076	0.062	0.050	0.074	< 0.001
Number of healthcare staff					
Medical doctor	0.013	0.145	−0.010	0.299	0.066
Nurse	0.021	0.149	0.028	0.270	0.016
Registered dietitian (≥ 1 /ward)	0.009	0.680	−0.399	1.759	0.217

FIM, Functional Independence Measure; β , standardized partial regression coefficient; *B*, partial regression coefficient; CI, confidence interval; KRW, Kaifukuki (convalescent) rehabilitation ward; BMI, body mass index.

¹ Overall, 294 data of patients were excluded for the analysis due to missing value, ² $R^2=0.742$.

with RD showed higher changes in body weight and BMI (both $p<0.001$). There was no difference in length of stay ($p=0.614$) as well as discharge disposition ($p=0.339$).

Table 3 shows the results of the multiple regression analysis for changes in body weight. Based on the results of the univariate analysis, age, sex, length of KRW stay, FIM, BMI, number of KRW beds, daily rehabilitation dose, and number of medical doctors and nurses were included as confounders. Consequently, younger age, female sex, longer length of KRW stay, higher FIM, lower BMI at admission, and higher dose of daily rehabilitation were independently associated with higher changes

in body weight ($R^2=0.051$). Additionally, assignment of RDs ($B=0.213$, 95% confidence interval [CI], 0.036–0.389) and number of nurses ($B=0.023$, 95% CI, 0.003–0.043) were significantly associated with weight gain. Subgroup analysis indicated that the number of nurses ($B=0.028$, 95% CI, 0.003–0.054) and daily rehabilitation dose ($B=0.003$, 95% CI, 0.000–0.005) positively affected the slight change in body weight of fragile fracture patients, whereas the assignment of RDs affected the small gain of body weight in stroke patients ($B=0.352$, 95% CI, 0.032–0.671).

Table 4 indicates the results of the multiple regression analysis for BMI at discharge ($R^2=0.558$). Similar to

change in body weight, assignment of RDs ($B=0.095$, 95% CI, 0.023–0.166) and number of nurses ($B=0.009$, 95% CI, 0.001–0.017) were also predicted higher discharge BMI. Subgroup analysis showed that the similar effect of number of nurses positively ($B=0.012$, 95% CI, 0.001–0.023) and daily rehabilitation dose ($B=0.001$, 95% CI, 0.000–0.002) on BMI of fragile fracture patients, as well as the effectiveness of assignment of RD on BMI of stroke patients ($B=0.150$, 95% CI, 0.026–0.274).

Table 5 shows results of the multivariable analysis for the discharge FIM ($R^2=0.742$). The number of nurses ($B=0.149$, 95% CI, 0.028–0.270) was significantly associated with higher FIM score whereas assignment of RDs ($p=0.217$) and the number of medical doctors ($p=0.066$) did correlate with FIM at discharge. In the subgroup analysis, only FIM of fragile fracture patients was affected by the number of healthcare staff. The number of medical doctors ($B=0.245$, 95% CI, 0.038–0.452) and nurses ($B=0.328$, 95% CI, 0.157–0.499) were independently associated with higher FIM at discharge. However, no correlation was found between assignment of RDs and FIM at discharge.

Binary logistic regression analysis revealed that higher admission FIM (odds ratio [OR]=1.044, 95% CI, 1.041–1.047), admission BMI (OR=1.075, 95% CI, 1.027–1.124), and higher rehabilitation dose (OR=1.004, 95% CI, 1.002–1.005) independently predicted high probability of home discharge, whereas older age (OR=0.990, 95% CI, 0.984–0.995) negatively impacted home discharge ($R^2=0.309$). The number of healthcare staff did not predict home discharge.

DISCUSSION

This study was based on an analysis of a high-response, nationwide survey that included >60% of KRWs in Japan and revealed several clinical findings. First, the assignment of RDs in KRW was significantly associated with higher weight gain and BMI at discharge among underweight patients in inpatient rehabilitation units, especially stroke patients. Second, the number of nurses and time of rehabilitation therapy were also associated with BMI gain, particularly for those with fragile fracture. Third, no correlation was found for assignment of RDs with FIM or home discharge.

RDs play a major role in nutritional care of patients in the hospital, including inpatient rehabilitation units or facilities (9–12, 15). The present results highlight the potential effectiveness of assignment of RDs on nutritional outcome of patients undergoing rehabilitation. This finding is clinically plausible, as previous studies reported that nutritional recommendations or documentation of nutritional requirements may increase energy intake (10, 16). Additionally, nutritional intervention may increase the provision of energy and proteins, as reported in a meta-analysis (17). Moreover, patients in an inpatient rehabilitation setting may readily gain weight from high energy intake because of a longer length of stay, which provides a longer period for receiving nutritional support compared to those

in an acute care setting. On the other hand, routine nutritional monitoring and the assessment of activity-related energy expenditure, which is further affected by the rehabilitation program and functional recovery, can also play an important role in preventing weight loss. In fact, more frequent monitoring of nutritional status by an RD may contribute to a positive BMI change in KRW (12). Although the magnitude of the effect of assignment of RDs was not high ($\beta=0.024$), RDs' clinical practice can help to improve patients' nutritional status.

In this study, the number of nurses and daily rehabilitation dose had favorable effects on weight gain and BMI. The positive relationship between the number of nurses and body weight is clinically sound and is further supported by a study suggesting that having a smaller nursing professional-to-bed ratio was associated with failure to achieve daily caloric need in intensive care unit patients (18). These findings can be attributed to the frequent performance of daily clinical care by nurses, such as assistance with meal intake, administration of enteral/parenteral nutrition, and measuring of body weight. Similarly, daily rehabilitation dose was positively associated with BMI at discharge. This finding is interesting, as exercise is thought to suppress appetite by altering levels of appetite-regulating hormones such as acylated ghrelin, peptide YY, glucagon-like peptide-1, and pancreatic polypeptide (19), thus the high dose of daily rehabilitation might be accompanied by a relatively decreased energy intake. However, rehabilitation therapy includes not only intensive exercise such as resistance training, but also low-intensity training (e.g., cooking, writing, and vocalization) that might stimulate the appetite (20). Future studies are warranted regarding the effect of the type of rehabilitation program and energy intake in consideration with the type of nutritional support (i.e., oral intake, enteral/parenteral nutrition).

On the contrary, the FIM and home discharge were not affected by whether or not RDs were assigned. This finding is consistent with previous studies regarding nutritional intervention, indicating that even when performed with rehabilitation, nutritional intervention did not improve functional recovery (21, 22). Additionally, the effect of assignment of RDs on BMI gain (0.1 kg/m^2) was lower than the minimum clinically important difference of BMI (0.7 kg/m^2) (23). Therefore, it is possible that greater BMI gain will be required to improve the ADL of underweight patients. However, the potential effect of nutritional intervention in persons with disabilities is evident, as several nutritional intervention trials show that oral nutritional supplementation with specific nutrients (e.g., branched amino acid) increase muscle mass, strength, or functions in patients with functional limitations, undernutrition, or sarcopenia (24–28). Since this survey did not include data on muscle mass, future intervention trials are needed to focus on the effect of clinical nutrition practice on the rehabilitation outcomes of patients with malnutrition or sarcopenia and muscle mass gain. On the other hand, daily rehabilitation dose and the number of nurses

were positively associated with FIM at discharge. The former finding concurs with previous studies showing that sufficient duration of rehabilitation therapy positively impacts functional outcome (14, 29). Meanwhile, a higher number of rehabilitation nurses results in more daily activities in the unit, which can achieve higher ADL. However, this finding remains inconclusive because of the relatively small effect of nurses on FIM ($\beta=0.021$); in addition, the activity they perform for the patients remain poorly defined.

There were several limitations in this study. First, this survey did not investigate the specific activities performed for each patient by RDs and other healthcare professionals. Therefore, it remains unclear concerning which practice positively affects weight gain. Second, there may be a potential effect of selection bias on the results because the FIM at admission for several included patients was higher than FIM of excluded patients. Thus, whether the current findings can be extrapolated to patients with severe disabilities require further investigation. Third, body composition was not included in the survey. Since the muscle mass/strength may be more directly associated with functional outcome than body weight per se, further studies are needed. Fourth, although the number of KRW beds and daily rehabilitation dose were adjusted by multivariate analysis, unrecognized confounders in each KRW might affect the findings of our study. Finally, our results could be biased by heterogeneity of diseases and comorbidities. Although subgroup analyses were performed for several disease/condition groups; these categories differed from accurate diagnosis based on standardized criteria such as the International Classification of Diseases.

In conclusion, the current results revealed the positive effects of assignment of RDs, number of nurses, and daily rehabilitation dose on changes in body weight and BMI at discharge. On the other hand, assignment of RDs showed no effect on functional outcome. These results may be generalized to underweight patients in inpatient rehabilitation units/facilities around the world; furthermore, they emphasize the importance of nutritional professionals in the inpatient rehabilitation setting. These findings may evoke further investigation regarding daily clinical practice of nutritional professionals in inpatient rehabilitation facilities/units in different countries.

Disclosure of state of COI

No conflicts of interest to be declared.

Acknowledgments

We are grateful to Maki Urushihara, RD; Yumiko Kiriya, RD; Misuzu Watanabe, RD; Keiko Shintani, RD; Hiromi Nakagomi, RD; Noriko Kageyama, RD; and directors of the KRW Association for their advice and expertise regarding this study, as well as all participating facilities of the annual survey for their responses.

REFERENCES

- 1) Marshall S, Young A, Bauer J, Isenring E. 2016. Malnutrition in geriatric rehabilitation: prevalence, patient outcomes, and criterion validity of the Scored Patient-Generated Subjective Global Assessment and the Mini Nutritional Assessment. *J Acad Nutr Diet* **116**: 785–794.
- 2) Sánchez-Rodríguez D, Marco E, Annweiler C, Ronquillo-Moreno N, Tortosa A, Vázquez-Ibar O, Escalada F, Duran X, Muniesa JM. 2017. Malnutrition in postacute geriatric care: Basic ESPEN diagnosis and etiology based diagnoses analyzed by length of stay, in-hospital mortality, and functional rehabilitation indexes. *Arch Gerontol Geriatr* **73**: 169–176.
- 3) Nishioka S, Wakabayashi H, Yoshida T. 2017. Accuracy of non-paralytic anthropometric data for nutritional screening in older patients with stroke and hemiplegia. *Eur J Clin Nutr* **71**: 173–179.
- 4) Slattery A, Wegener L, James S. 2015. Does the Mini Nutrition Assessment—Short Form predict clinical outcomes at six months in older rehabilitation patients? *Nutr Diet* **72**: 63–68.
- 5) Nishioka S, Okamoto T, Takayama M, Urushihara M, Watanabe M, Kiriya Y, Shintani K, Nakagomi H, Kageyama N. 2017. Malnutrition risk predicts recovery of full oral intake among older adult stroke patients undergoing enteral nutrition: Secondary analysis of a multicentre survey (the APPLE study). *Clin Nutr* **36**: 1089–1096.
- 6) Marshall S, Young A, Bauer J, Isenring E. 2016. Nutrition screening in geriatric rehabilitation: criterion (concurrent and predictive) validity of the Malnutrition Screening Tool and the Mini Nutritional Assessment-Short Form. *J Acad Nutr Diet* **116**: 795–801.
- 7) Nishioka S, Wakabayashi H, Nishioka E, Yoshida T, Mori N, Watanabe R. 2016. Nutritional improvement correlates with recovery of activities of daily living among malnourished elderly stroke patients in the convalescent stage: a cross-sectional study. *J Acad Nutr Diet* **116**: 837–843.
- 8) Nishioka S, Wakabayashi H, Momosaki R. 2018. Nutritional status changes and activities of daily living after hip fracture in convalescent rehabilitation units: a retrospective observational cohort study from the Japan Rehabilitation Nutrition Database. *J Acad Nutr Diet* **118**: 1270–1276.
- 9) Phillips W. 2018. Identifying and documenting malnutrition in inpatient rehabilitation facilities. *J Acad Nutr Diet pii*: S2212-2672(17)31403-X.
- 10) Wakeham M, Christensen M, Manzi J, Kuhn EM, Scanlon M, Goday PS, Mikhailov TA. 2013. Registered dietitians making a difference: early medical record documentation of estimated energy requirement in critically ill children is associated with higher daily energy intake and with use of the enteral route. *J Acad Nutr Diet* **113**: 1311–1316.
- 11) Imfeld K, Keith M, Stoyanoff L, Fletcher H, Miles S, McLaughlin J. 2012. Diet order entry by registered dietitians results in a reduction in error rates and time delays compared with other health professionals. *J Acad Nutr Diet* **112**: 1656–1661.
- 12) Nishioka S, Sugawara H, Takayama M, Urushihara M, Watanabe M, Kiriya Y, Shintani K, Nakagomi H, Kageyama N, Okamoto T, Sumita S, Fujita M, Hashimoto S, Ishikawa M, Tsushima E, Ogawa A. 2018. Relationship between weight gain, functional recovery and nutrition monitoring in underweight tube-fed stroke patients. *Jpn J Compr Rehabil Sci* **9**: 3–10.
- 13) Miyai I, Sonoda S, Nagai S, Takayama Y, Inoue Y, Kakehi

- A, Kurihara M, Ishikawa M. 2011. Results of new policies for inpatient rehabilitation coverage in Japan. *Neurorehabil Neural Repair* **25**: 540–547.
- 14) Ottenbacher KJ, Hsu Y, Granger CV, Fiedler RC. 1996. The reliability of the functional independence measure: A quantitative review. *Arch Phys Med Rehabil* **77**: 1226–1232.
- 15) The Academy Quality Management Committee. 2018. Academy of Nutrition and Dietetics: revised 2017 Scope of Practice for the registered dietitian nutritionist. *J Acad Nutr Diet* **118**: 141–165.
- 16) Braga JM, Hunt A, Pope J, Molaison E. 2006. Implementation of dietitian recommendations for enteral nutrition results in improved outcomes. *J Am Diet Assoc* **106**: 281–284.
- 17) Collins J, Porter J. 2015. The effect of interventions to prevent and treat malnutrition in patients admitted for rehabilitation: A systematic review with meta-analysis. *J Hum Nutr Diet* **28**: 1–15.
- 18) Honda CK, Freitas FG, Stanich P, Mazza BF, Castro I, Nascente AP, Bafi AT, Azevedo LC, Machado FR. 2013. Nurse to bed ratio and nutrition support in critically ill patients. *Am J Crit Care* **22**: e71–e78.
- 19) Hazell TJ, Islam H, Townsend LK, Schmale MS, Copeland JL. 2016. Effects of exercise intensity on plasma concentrations of appetite-regulating hormones: Potential mechanisms. *Appetite* **98**: 80–88.
- 20) Deighton K, Stensel DJ. 2014. Creating an acute energy deficit without stimulating compensatory increases in appetite: is there an optimal exercise protocol? *Proc Nutr Soc* **73**: 352–358.
- 21) Beck AM, Dent E, Baldwin C. 2016. Nutritional intervention as part of functional rehabilitation in older people with reduced functional ability: a systematic review and meta-analysis of randomised controlled studies. *J Hum Nutr Diet* **29**: 733–745.
- 22) Bally MR, Blaser Yildirim PZ, Bounoure L, Gloy VL, Mueller B, Briel M, Schuetz P. 2016. Nutritional support and outcomes in malnourished medical inpatients: A systematic review and meta-analysis. *JAMA Intern Med* **176**: 43–53.
- 23) Wouters EFM. 2005. Minimal clinically important differences in COPD: body mass index and muscle strength. *COPD* **2**: 149–155.
- 24) Ha L, Hauge T, Spenning AB, Iversen PO. 2010. Individual, nutritional support prevents undernutrition, increases muscle strength and improves QoL among elderly at nutritional risk hospitalized for acute stroke: A randomized, controlled trial. *Clin Nutr* **29**: 567–573.
- 25) Beck AM, Christensen AG, Hansen BS, Damsbo-Svendsen S, Møller TK. 2016. Multidisciplinary nutritional support for undernutrition in nursing home and home-care: A cluster randomized controlled trial. *Nutrition* **32**: 199–205.
- 26) Yoshimura Y, Bise T, Sayuri PT, Tanoue M, Tomioka Y, Araki M, Nishino T, Kuzuhara A, Takatsuki F. 2018. Effects of a leucine-enriched amino acid supplement on muscle mass, muscle strength, and physical function in post-stroke patients with sarcopenia: a randomized controlled trial. *Nutrition* **58**: 1–6.
- 27) Yoshimura Y, Uchida K, Jeong S, Yamaga M. 2016. Effects of nutritional supplements on muscle mass and activities of daily living in elderly rehabilitation patients with decreased muscle mass: a randomized controlled trial. *J Nutr Health Aging* **20**: 185–191.
- 28) Bouillanne O, Curis E, Hamon-Vilcot B, Nicolis I, Chrétien P, Schauer N, Vincent JP, Cynober L, Aussel C. 2013. Impact of protein pulse feeding on lean mass in malnourished and at-risk hospitalized elderly patients: A randomized controlled trial. *Clin Nutr* **32**: 186–192.
- 29) Veerbeek JM, Koolstra M, Ket JCF, Van Wegen EEH, Kwakkel G. 2011. Effects of augmented exercise therapy on outcome of gait and gait-related activities in the first 6 months after stroke: A meta-analysis. *Stroke* **42**: 3311–3315.