Original Article

Energy requirements for patients in convalescent rehabilitation using motor scores as in the Functional Independent Measure

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Background and Objectives: Although appropriate nutrition management could improve rehabilitation outcomes, more than 40 % of patients in a convalescent rehabilitation ward (CRW) suffer from malnutrition. The study was undertaken to investigate whether adequate nutrition for each patient in a CRW could be estimated based on motor scores on the Functional Independence Measure (FIM-M). **Methods and Study Design:** In 218 patients in our CRW, both basal energy expenditure (BEE) on admission and average energy intake (EI) for 2 weeks were calculated, and EI was divided by BEE to estimate the activity index (e-AI). The patients were classified according to FIM-M to investigate the relationship between the FIM-M and the e-AI. **Results:** The e-AI tended to increase in proportion to the FIM-M. In the N group, where the increase-decrease rate for body weight was within 2%, the e-AI induced by a FIM-M greater than 60 was significantly higher than that induced by a FIM-M up to 60 (1.3 vs 1.1, $p<0.01$). Compared to the N group, altering the e-AI caused the same tendency of body weight change in patients with FIM-M greater than 60 and up to 60. **Conclusions:** The FIM-M could provide a criterial activity index for patients in a CRW when their energy requirement is appropriately estimated, considering the intensity of their physical activity.

Key Words: energy requirement, Functional Independent Measure (FIM), motor scores on FIM (FIM-M), activity index, convalescent rehabilitation

INTRODUCTION

The convalescent rehabilitation ward (CRW) provides intensive rehabilitation to improve the activities of daily living (ADL) and to facilitate discharge to home. CRWs were established in the year 2000, and have been increasing year by year in Japan.[1] Most of the patients hospitalized in the CRW are elderly, and are admitted after treatment for acute diseases such as cerebrovascular diseases, orthopedic diseases including hip fracture and hip replacement arthroplasty, among others. It has been reported that post-stroke patients who were overweight (body mass index (BMI) approximately 25-27 kg/m^2) could obtain favorable functional recoveries (as defined by a modified Rankin Scale score of 0-1). The highest Functional Independent Measure (FIM) efficiency, which is calculated by the change in FIM from admission to discharge/the length of hospital stay, was achieved after rehabilitation compared with other BMI groups, whereas FIM efficiency was lowest in the underweight post-stroke patients (BMI less than 18.5 kg/m^2).[2,3] Moreover, severely obese, post-stroke patients (BMI greater than approximately 30 kg/m^2) had a high 3-month mortality and a low FIM efficiency.[2,3] On the other hand, nutritional interventions after surgery in elder patients with hip fractures improved postoperative outcomes and prevented declines in quality of life.[4,5] Accordingly, appropriate nutrition management could improve rehabilitation outcomes and is one of the most important issues in the CRW. Nevertheless, more than 40 % of patients in the CRW suffer from malnutrition.[6-8]

Several screening methods of nutritional status for patients have been proposed, such as the Subjective Global Assessment (SGA) and the Mini Nutritional Assessment (MNA), among others. However, body weight (BW) is the easiest parameter to measure, and its change provides a useful index of malnutrition. For instance, a 1-2% reduction in BW over the course of a week is consistent with malnutrition. To perform effective rehabilitation in a CRW, it is necessary to offer adequate nutrition without unintentional BW changes (both BW losses and BW gains) in response to the physical activity of individual

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Manuscript received 04 July 2018. Initial review completed 21 August 2018. Revision accepted 14 September 2018.
doi:

patients. In this study, we investigated whether adequate nutrition for each patient in a CRW could be estimated based on the FIM, one of the indicators of ADL,[9-11] using daily energy intake (EI) and BW change.

METHODS

Procedure

This study was carried out with the approval of the ethical committee of our hospital. We extracted the data of patients who were admitted to our CRW and stayed more than 2 weeks between September 2016 and February 2017. The basal energy expenditure (BEE) was calculated for all the patients according to the Harris-Benedict Equation. Based on the meal contents, including supplementary food, and the intake amounts for 2 weeks after admission, the average daily EI of each patient was calculated. The average daily EI was divided by the BEE to estimate the activity index (e-AI; e-AI = EI / BEE). The FIM motor scores (FIM-M) for each patient were evaluated by the staff of the rehabilitation unit upon admission.

According to their BW changes during the 2-week period after admission, the patients in this study were divided into 3 groups as follows: the increase-decrease rate of BW was within 2%, which was defined as the no-change (N) group. The patients whose BW increased and decreased more than 2% were grouped into an increase (I) group and a decrease (D) group, respectively.

To investigate the relationship between the FIM-M and the e-AI, each of the 3 groups was subdivided into 8 subgroups: 13-20, 21-30, 31-40, 41-50, 51-60, 61-70, 71-80, and 81-91. The average e-AI in one subgroup was compared to other subgroups. The N, I and D groups were further subdivided into two groups depending on whether the FIM-M was more than 60 or up to 60, which created a total of six subgroups. Then, the average e-AI in one subgroup was compared to the others.

Statistical analysis

All analyses were performed using JMP version 6, Japanese Edition (SAS Institute Inc., Cary, NC, USA). All results are expressed as the mean ± SD. The differences among multiple groups were determined using a one-way analysis of variance (ANOVA). The significance of the individual differences was evaluated using Tukey-Kramer's procedure as a post hoc test. A *p*-value of less than 0.05 was considered statistically significant.

RESULTS

Of 237 patients hospitalized in our CRW between September 2016 and February 2017, 19 were discharged within 2 weeks, and 218 patients were included in this study (men:women = 100:118, average age 74.6±12.2 years)(Table 1). The maximum and minimum values of the BEE calculated using the Harris-Benedict Equation were 2028.4 and 747.2 kcal/day, respectively.

The N group consisted of 73 men and 73 women (average age 74.8±11.4 years). The e-AI tended to increase in proportion to the FIM-M. While the e-AI was approximately 1.0 when the FIM-M was up to 30, the e-AI was elevated to greater than 1.3 when the FIM-M was greater than 60. When the FIM-M was 61-70, the e-AI significantly increased compared to FIM-Ms of 13-20 and 21-30 ($p<0.01$) (Table 2). There were 15 men and 16 women in the I group (average age 71.5±15.7 years), and the D

Table 1. Characteristics of the 218 patients in this study[†]

Causative disease	N (M/W)	%	Age
Cerebrovascular disease	74 (36/38)	33.9	73.6±10.8
Fracture due to osteoporosis	61 (18/43)	28.0	80.0±9.5
Total hip arthroplasty	29 (7/22)	13.3	71.3±10.3
Spine disorder	19 (12/7)	8.7	80.1±8.3
Spinal cord injury	12 (10/2)	5.5	66.2±11.9
Head trauma	7 (5/2)	3.2	75.9±6.9
Disuse syndrome	5 (3/2)	2.3	81.2±5.0
Others	11 (9/2)	5.0	55.5±21.2
Total	218 (100/118)		74.57

[†] Values are means±SD.

Table 2. The e-AI in each class according to the FIM-M of each group[†]

FIM-M	Decrease group		No-change group		Increase group	
	e-AI	N (M/W)	e-AI	N (M/W)	e-AI	N (M/W)
13-20	0.96±0.31	8 (1/7)	1.04±0.33[*]	17 (9/8)	0.74	1 (1/0)
21-30	1.07±0.28	6 (2/4)	0.99±0.28[*]	15 (6/9)	1.00±0.15	3 (1/2)
31-40	1.08±0.49	3 (1/2)	1.24±0.29	16 (8/8)	1.20±0.12	7 (5/2)
41-50	1.18±0.27	9 (2/7)	1.12±0.24	22 (9/13)	1.28±0.19	4 (1/3)
51-60	1.07±0.22	6 (3/3)	1.21±0.30	36 (24/12)	1.24±0.24	4 (0/4)
61-70	1.20±0.28	7 (2/5)	1.34±0.23	32 (11/21)	1.35±0.32	10 (5/5)
71-80	1.45±0.15	2 (1/1)	1.37±0.28	7 (5/2)	1.34±0.06	2 (2/0)
81-91	-		0.77	1 (1/0)	-	-
Total		41 (12/29)		146 (73/73)		31 (15/16)

e-AI: estimated activity index; FIM-M: FIM motor score; FIM: Functional Independent Measure.

[†] Values are means ± SD. Significantly differences were seen in the e-AI when the FIM-M was 61-70 in the no-change group.

[*] $p<0.05$.

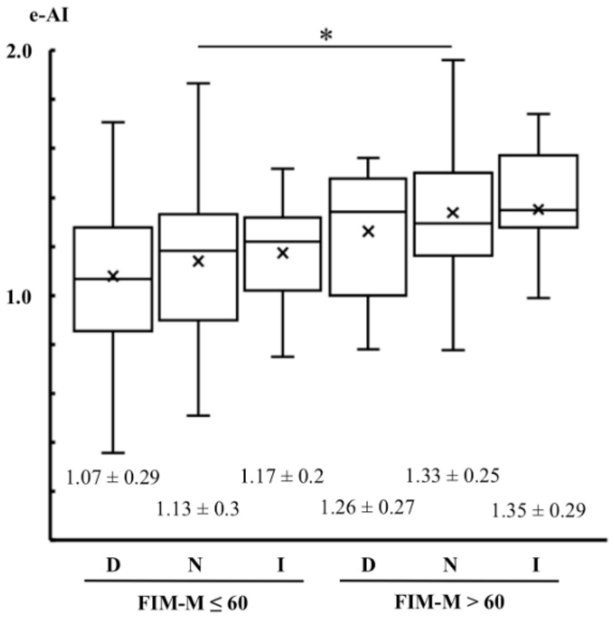

Figure 1. Boxplots of e-AI classified by FIM-M in the D, N, and I groups. The crosses represent the average value in each subgroup, which is expressed as mean ± SD below each boxplot. The e-AI increases in proportion to the body weight and the FIM-M. In the N group, the e-AI induced by a FIM-M greater than 60 is significantly higher than that induced by a FIM-M up to 60 ($^{*}p<0.05$). D: decrease group; N: no-change group; I: increase group; e-AI: estimated activity index; FIM-M: FIM motor score; FIM: Functional Independent Measure.

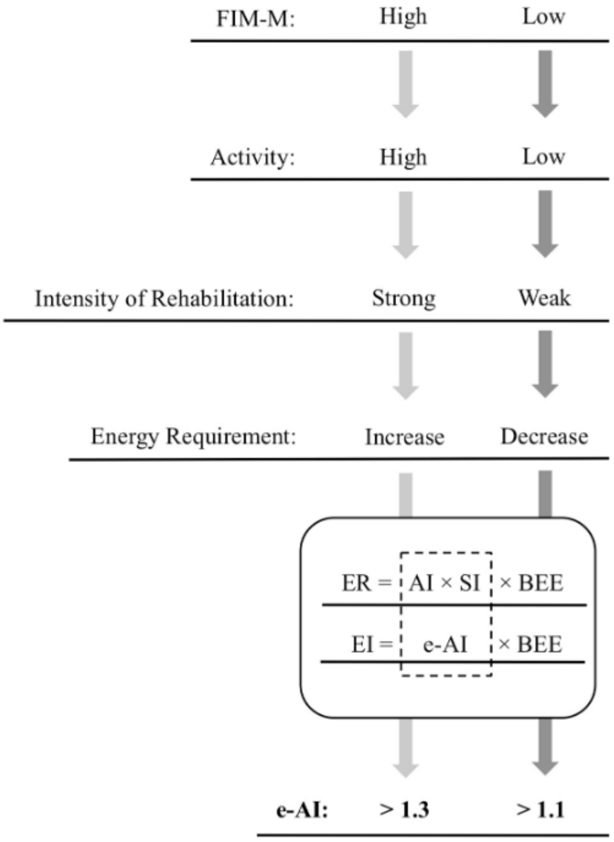

Figure 2. The explanatory diagram of this study. FIM-M: motor scores on the Functional Independent Measure; ER: energy requirement; AI: activity index; SI: stress index; BEE; basal energy expenditure; e-AI: estimated AI.

group included 12 men and 29 women (average age 76.0±12.0 years). Changes in the e-AI based on the FIM-M in the I and D groups were similar to the N group, but without significant differences (*p*=0.169 and *p*=0.43, respectively) (Table 2).

In the N group, the e-AI induced by a FIM-M greater than 60 was significantly higher than that induced by a FIM-M up to 60 (1.33±0.25 vs 1.13±0.3; *p*<0.01) (Figure 1). Additionally, the e-AI in the I and D groups tended to be higher and lower than that in the N group, respectively, regardless of the FIM-M (Figure 1).

DISCUSSION

The energy requirement (ER) is calculated by multiplying the activity index (AI) and stress index (SI) by the BEE (ER = BEE x AI x SI).[12] In this study, because the ER was almost equivalent to the EI (EI = BEE x e-AI), the e-AI was also equivalent to the product of the AI and the SI in the formula estimating the ER. Of 218 cases, only three patients suffered from pressure ulcers (not shown). Although it is one of the factors elevating the SI, it is possible that the e-AI would not be affected by its existence in this study. Considering the aim of the CRW, any injuries, operations, infections, and burns were treated by acute hospitalization.[13] Thus, the SI was close to 1.0, and the e-AI was similar to the AI in this study (Figure 2).

The AI is calculated according to the active state of the individual. For instance, the AIs of individuals who are bedridden and conscious, versus those who are able to get out of bed, versus those who are active and can routinely work are 1.1 vs. 1.3 vs. 1.5, respectively. It has been also proposed that an AI of 1.3-1.5 should be applied to patients entering a CRW.[14] In this study, the BW of patients whose FIM-M was greater than 60 did not change when the e-AI was 1.3. On the other hand, it is thought that 200-500 kcal/day should be added to daily ER to increase the BWs of underweight patients undergoing rehabilitation.[15] Since the BEE in this study was 750 to 2,000 kcal/day, which would imply that an e-AI of 0.2 is approximately equal to 150 to 400 kcal/day, an e-AI of 0.2 should be added to an e-AI of 1.3 when the patients need to increase their BW. A FIM-M greater than 60 in patients in a CRW indicates that they can perform most ADL for themselves, whereas patients whose FIM-M is below 60 would need assistance with their ADLs. Thus, an e-AI of 1.3 would be the minimum required for rehabilitation in a CRW (for patients who are more physically active than low FIM-M patients) without reducing BW. Similarly, an e-AI of 1.1 is the minimum required to maintain BW in low FIM-M patients (Figure 2).

This study was conducted in a CRW that belongs to a district hospital. As mentioned above, the numbers of CRWs have been increasing since the year 2000 in Japan. It is estimated that the number of CRW beds will approach 375,000 by 2025, which would be approximately equivalent to 30% of the total number of hospital beds in Japan. However, the components of foods provided to patients in a CRW would not be much different between hospitals, because the diets provided by most hospitals, including our hospital, are made in accordance with the "Dietary Reference Intakes for Japanese (2015)"[16] issued by the Minister of Health, Labor, and Welfare. Moreover, patients who are in stable condition after acute-phase treatment would be hospitalized for up to 6 months in a CRW, while the length of stay in the acute hospital is 2 weeks or less. Accordingly, it will be necessary to conduct similar investigations in other institutions to apply the results of our study to the majority of CRW patients. However, it is possible that the results obtained in other investigations might be similar to those of this study.

Since rehabilitation is vigorously conducted over a long period for patients in CRWs, each patient's ER will be different from others depending on their condition and the intensity of their physical activity. The results of this study provide index criteria for patients in a CRW when ER is appropriately estimated considering the intensity of physical activity.

AUTHOR DISCLOSURES

The authors declare neither conflict of interest nor financial relationship.

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