Original

Resting Energy Expenditure of the Unhealthy Elderly in the “Roken” in Japan

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Abstract

Background: To know actual conditions and a balance between food intake and energy expenditure of each of the elderly in the super-aged society is very important.

Aim: To determine the resting energy expenditure (REE) of the elderly residing in the “Roken”.

Methods: For Study 1, REEs of 47 elderly people in the Roken were measured. For Study 2, REEs of 22 patients who were admitted to a general hospital were measured.

Results: In Study 1, REE of the elderly people in the Roken ranged from 523 to 1,628 kcal/day/body; the mean value was 909 ± 239 kcal/day/body (mean $\pm$ SD) and 21.6 ± 4.5 kcal/kg/day. A discrepancy between REE and dietary energy intake was observed.

In Study 2, REE of patients in the hospital widely ranged from 589 to 2,549 kcal/day/body; the mean value was 1391 ± 459 kcal/day/body (mean $\pm$ SD).

Conclusions: The mean value of REE of the elderly in the Roken was 74% lower than that of the healthy individuals in previous reports. The observed discrepancy between REE and dietary energy intake suggested the need for improvement in the effective absorption of nutrients from the digestive system, which may be more important than food intake.

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Introduction

Currently, there is a need to determine the energy expenditure (EE) of the elderly, particularly in those who are frail or disabled, and there is also a need to identify the optimal resting energy expenditure (REE) for the elderly in the “Roken”, which is a geriatric services facility in Japan^{1,2}.

The REE is clinically measured to evaluate the EE better than the basal energy expenditure (BEE) because of the needs of strict measuring conditions for BEE.

The government of Japan has responded to various issues associated with the rapid growth of the aging population by developing various programs that have promoted health care, medical care, and welfare of the elderly, including the Roken. The Roken is a geriatric services facility in Japan that has been mandated to serve as an intermediary facility for hospitals, homes, and nursing homes. The Roken provides new and unique services that include both medical and welfare services for the elderly. The mission of the Roken is to allow a person who requires long-term care to live a long and meaningful life. Its original purpose of improving the user's level of functioning to permit a return home remains in place to date; however, some users are disabled and could not go home.

In Japan, artificial routes of nutrition through the use of a nasogastric tube or percutaneous endoscopic gastrostomy tube are often provided for the elderly.

The absorptive effectiveness of alimentary therapy appears to widely vary; for example, some individuals gained weight with an intake of 800 kcal/day, whereas others achieved and maintained a constant weight with an intake of 1,600 kcal/day, regardless of having the same low level of daily activity and remaining in bed all day long (unpublished observation).

The ideal or adequate EE or its requirements of individuals have been previously established.^{3,4} However, information on the relationship between EE and energy requirements, particularly the data related to the rapidly-growing aging population, remains been limited.

We therefore examined REE of elderly in the Roken who were unhealthy and were either frail or disabled. This study is designed as a kind of factual survey for the elderly in the Roken for the first time in the super-aged society in Japan.

Methods

Study 1 involving 47 subjects from the Roken

REEs were measured in 47 subjects who were receiving long-term care services and who were admitted to the “Roken Ichiyokan”(http://www.maroon.dti.ne.jp/sheep2/top.html). A Roken is a geriatric services facility in Japan that provides care and assistance to elderly persons who are either frail or disabled and who have low physical activity levels. The 47 subjects comprised 38 females and 9 males. Of these patients, 1 was in the 60s, 9 were in their 70s, 21 were in their 80s, 15 were in their 90s, and 1 was 100 years old. The average age of the study population was 85.2 ± 7.6 (mean ± SD) years (range: 66–100 years).

REE was measured by indirect calorimetry (VMB-005N Vine Tokyo, Japan). The measuring methodology is described in detail elsewhere.^{5–8} REE was measured for 3 min in a stable general condition, recumbent, or semi-recumbent position at room tem-

Table 1 The equation formulae for the blood gas analysis derived from Fick’s equation. Calorimetry was determined by calculating the oxygen expenditure as 1 mL of oxygen = 5 calories.

$\dot{V}O_2$ (ml/min) = $CO \times (CaO_2 - CvO_2) \times 10$
CaO_2 (ml/dl) = $(Hb \times 1.34 \times SaO_2/100) + (PaO_2 \times 0.0031)$
CvO_2 (ml/dl) = $(Hb \times 1.34 \times SvO_2/100) + (PaO_2 \times 0.0031)$

peratures of 23–20°C, after at least 1 h postprandially and after>30 min of rest.

These measurements were conducted after receiving informed consent from the patients themselves or from their guardians.

Study 2 involving an another group of population as a reference or control.

Another group comprised 22 patients, 8 females and 14 males, with ages ranging from 70 to 90 years. Each patient was troubled with some disease, and the patients were non-frail, frail, or disabled. The average age of this group, which was collected from the previous medical records of patients treated between 1993 and 2001 at the general hospital, National Hospital Organization Numata National Hospital, was 77.5 ± 6.0 (mean ± SD) years.

REEs were calculated by Fick’s equation (table 1) from the gas analysis from the Swan-Ganz catheterization of the right hearts of subjects who were suspected of having either pulmonary hypertension or pulmonary thromboembolism and were thus admitted to the hospital after providing informed consent. All the patients of this group were unhealthy and comprised individuals who were non-frail, frail, or disabled.

The measuring condition were in a recumbent position after at least 1 h postprandially and after>30 min of rest but unclear in a relaxing state or nervous. We compared REEs of these patients with those from the Roken and used as a references of another population.

The statistical data are expressed as the mean ±

Figure 1 Frequency distribution of REEs of the elderly who resided in the Roken, which showed a normal Gaussian distribution and mean value of 909 ± 239 (mean ± SD) kcal/day/body. All the elderly were unhealthy and were either frail or disabled.

SD. The linear regression analysis was done by using Microsoft® Excel® 2010.

Results

Study 1

The REE/body of each of the 47 subjects ranged from 623 to 1,628 kcal/day/body; the mean value was 909 ± 239 (mean $\pm$ SD) kcal/day/body and was 21.6 ± 4.5 kcal/kg/day (mean $\pm$ SD) (Table 2). Figure 1 shows the frequency distribution of the 47 subjects, which appeared to resemble a normal Gaussian distribution. The correlation coefficient between REE and the degrees of disability^{9,10} was $R = -0.158$ (Figure 2a) and that between REE/kg and the degrees of

disability was $R = -0.01$ (Figure 2b). No relationships were observed among the subjects.

However, as shown in Figure 3, a discrepancy between REE and dietary energy intake (F) was observed. The F/REE ratio of 28 persons without body weight gain nor loss was 1.4 ± 0.4 (mean $\pm$ SD) (Table 2), which indicated that the absorption rate of nutrients widely varied among these individuals.

Study 2

The REE/body of each of the 22 patients of the reference group ranged from 589 to 2,549 kcal/day/body; the mean value was 1391 ± 459 kcal/day/body (Table 3). The frequency distribution of these patients did not show a normal Gaussian distribution nor

Figure 2 (a) There was no significant correlation between REE and the degree of disability in the Roken. The degree of disability was defined as the gradual deterioration in the condition of daily life from A1 to C2. In A1, the elderly were unable to go outdoors without the aid of an attendant. In C2, the elderly were bedridden and unable to turn over alone. The evaluation methods of the degree of disability have been described in detail elsewhere.^{9,10} (b) There was no correlation between the REE/kg levels and the degree of disability.

Figure 3 The discrepancy between REE and dietary energy intake; (○) indicates body weight gain, (×) represents body weight being constant, and (△) shows body weight loss. Subjects above the diagonal line showed a dietary energy intake/REE that was greater than 1. One subject (a) had systemic edema, whereas another (b) was nervous. The two subjects depicted on the horizontal line were at an end-stage condition and could not eat. One subject (c) had a constant body weight that was maintained for 3 months, regardless of having a dietary intake of 1,600 kcal against REE of 800 kcal. Most subjects (×) were randomly distributed above the diagonal line.

Table 2 Resting energy expenditure (REE) measurements of the elderly in the Roken. REE of the elderly was measured in the Fowler or recumbent position at a resting state for ≥ 30 min and at least 1 h postprandially.

Case No.	Age	Sex	Body height (cm)	Body weight (kg)	Degree of disability	(a) REE (kcal/day)	REE/kg (kcal/kg/day)	Gain/loss of weight than 3months before	(b) Actual food intake (kcal/day)	(b)/(a)
1	82	♀	145.0	39.1	A2	1,103	28.2	↗	1,300	1.2
2	77	♀	153.1	49.6	B1	902	18.2	↗	1,400	1.6
3	80	♀	136.2	38.0	B2	860	22.6	↗	1,200	1.4
4	91	♀	154.5	38.5	A2	969	25.2	↗	1,440	1.5
5	70	♂	148.0	42.0	B2	1,058	25.2	↗	1,665	1.6
6	89	♀	136.0	47.0	B2	995	21.2	↗	1,300	1.3
7	81	♀	140.0	46.2	B2	1,221	26.4	↗	1,400	1.1
8	73	♀	145.5	43.5	B2	918	21.1	↗	1,200	1.3
9	92	♀	149.0	53.3	B2	1,369	25.7	↗	1,200	0.9
10	88	♀	130.0	35.8	B1	534	14.9	↗	1,200	2.2
11	94	♀	140.8	42.7	A2	979	22.9	→	1,100	1.1
12	85	♀	147.0	43.9	A2	815	18.6	→	1,400	1.7
13	87	♀	141.3	52.1	B2	1,137	21.8	→	1,200	1.1
14	66	♀	155.0	44.5	C2	747	16.8	→	840	1.1
15	82	♀	143.6	42.5	B1	968	22.8	→	1,200	1.2
16	82	♀	137.7	38.3	B2	553	14.4	→	1,200	2.2
17	90	♀	140.0	40.9	B2	949	23.2	→	1,444	1.5
18	86	♀	143.0	40.5	A2	523	12.9	→	1,400	2.7
19	93	♀	145.0	44.0	B2	779	17.7	→	1,344	1.7
20	74	♀	151.0	34.5	A2	842	24.4	→	1,200	1.4
21	97	♀	143.0	36.6	B2	906	24.8	→	1,444	1.6
22	78	♀	134.5	43.1	B2	964	22.4	→	1,200	1.2
23	94	♀	152.0	47.7	B2	1,628	34.1	→	1,600	1.0
24	82	♀	144.8	49.8	C2	917	18.4	→	800	0.9
25	98	♀	126.0	40.4	C1	617	15.3	→	800	1.3

26	86	♀	144.0	52.2	B2	1,163	22.3	→	1,300	1.1
27	81	♂	149.0	50.0	B2	1,392	27.8	→	1,400	1.0
28	79	♂	152.0	48.3	B2	772	16.0	→	1,200	1.6
29	94	♀	135.4	37.5	B2	840	22.4	→	1,200	1.4
30	90	♀	140.2	32.4	C2	672	20.7	→	800	1.2
31	89	♀	143.0	33.4	C2	660	19.8	→	450	0.7
32	83	♂	168.5	44.7	C2	1,115	24.9	→	1,200	1.1
33	81	♀	145.0	39.7	C2	1,111	28.0	→	1,400	1.3
34	100	♀	113.0	29.3	C2	623	21.3	→	800	1.3
35	81	♂	163.0	38.9	C2	629	16.2	→	1,400	2.2
36	85	♂	162.0	36.6	C2	808	22.1	→	1,600	2.0
37	78	♂	153.0	49.0	B2	1,137	23.2	→	1,300	1.1
38	96	♀	146.0	29.9	C2	755	25.3	→	800	1.1
39	90	♀	132.0	42.4	A2	971	22.9	↘	1,200	1.2
40	76	♂	156.0	53.3	C1	1,103	20.7	↘	1,644	1.5
41	78	♀	145.0	49.9	B2	670	13.4	↘	1,000	1.5
42	82	♀	150.2	54.4	B2	960	17.6	↘	1,000	1.0
43	93	♂	152.0	42.5	C2	637	15.0	↘	0	0.0
44	84	♀	148.0	43.9	B2	863	19.7	↘	1,200	1.4
45	90	♀	152.0	30.0	C2	684	22.8	↘	0	0.0
46	83	♀	145.0	40.4	C2	1,177	29.1	↘	435	0.4
47	93	♀	144.0	30.6	C2	733	24.0	↘	1,080	1.5

Table 3 REE of the inpatients of the hospital who were ≥ 70 years old calculated by Fick’s equation when examined by blood gas analysis using the Swan-Ganz right heart catheterization method.

Case No.	Sex	Age	Disease	BSA (m ²)	Date of examination	$\dot{V}O_2$ ml/m ² /min	$\dot{V}O_2$ ml/body/min	REE (kcal/day)
1	♂	70	COPD + PTE	1.48	12/2/1993	147	217	1,562
2	♂	71	COPD + PTE	1.27	11/5/1999	279	354	2,549
3	♂	71	CHF + PH	1.46	1/11/2000	123	180	1,296
4	♀	71	PTE	1.33	6/25/1999	104	138	996
5	♀	71	COPD + PH	1.52	4/9/1996	124	189	1,357
6	♂	72	COPD	1.38	11/5/1992	153	211	1,519
7	♂	73	CHF + PH	1.71	12/7/1999	174	298	2,146
8	♀	73	PTE ?	1.36	3/3/1999	130	177	1,273
9	♂	75	PTE	1.71	12/20/1991	151	258	1,858
10	♀	75	COPD+PH	1.1	7/16/1997	120	132	950
11	♀	77	mild CHF	1.5	3/21/2000	165	248	1,782
12	♂	77	PH + ASD	1.23	12/15/2000	197	242	1,745
13	♂	79	PTE	1.21	12/14/1994	124	150	1,080
14	♀	79	COPD + PH	1.14	4/19/1996	135	154	1,108
15	♂	79	PH ?	1.45	6/21/1999	76	110	794
16	♂	79	PH ?	1.45	6/23/1999	111	161	1,159
17	♂	80	PTE ?	1.42	4/14/1999	163	232	1,667
18	♂	83	CHF + PH	1.3	10/20/2000	125	163	1,171
19	♂	86	PH	1.5	9/14/1999	159	238	1,714
20	♀	86	PH	1.38	10/2/2001	123	170	1,222
21	♂	87	PTE	1.44	9/16/1998	103	148	1,068
22	♀	90		1.12	10/25/1996	73	82	589

$\dot{V}O_2$ =flow of oxygen, PTE=pulmonary thromboembolism, CHF=chronic heart failure, PH=pulmonary hypertension. ? denotes suspicion of disease.

Figure 4 Frequency distribution of REE of the inpatients in the hospital who were ≥ 70 years old and unhealthy, combined with the non-frail, frail, or disabled individuals.

resemble the distribution that was observed in Study 1 as shown in Figure 4.

Discussion

Hosoya et al¹¹ previously reported on REEs of a total of 6,498 healthy individuals in Japan; these participants ranged in age from 1 to 104 years. The REE/kg levels for the male and female subjects remained steady after the age of 15 years and were estimated to be approximately 29 kcal/kg for the male and female subjects. In addition, based on sex and age stratifications, these REEs showed a normal Gaussian distribution. They also showed that the mean value of REEs of the individuals who were older than 70 years was $1,665 \pm 437$ kcal/day/body.

The present study demonstrated that the mean REE of the unhealthy elderly individuals in Study 1 was 909 ± 239 kcal/day/body, which was 55% that of a healthy elderly individual, and was 21.6 ± 4.5 kcal/kg/day, which was 74% that of a healthy elderly individual, as described in the reports by Hosoya et al.

The individual actual EE could be obtained by calculating REE multiplied by the activity level. However, with low activity levels, Study 1 showed no correlation between REE of the elderly and the activity level during daily life in the population in the Roken. The degrees of the activity level was described in detail elsewhere.^{6,7} It means the value of REE would be near to the value of actual EE in the Roken. This may be due to the low activity level of the elderly in the Roken population.

As shown in Figure 3, discrepancies between REE and dietary energy intake without weight gain, even when the daily activity levels were considered, indicated that the absorptive factor of nutrition was more important than food intake.

In Study 2, REEs of the patients in the hospital,

comprising a combination of non-frail, frail, and disabled subjects, were widely varied and did not show a normal Gaussian distribution. Therefore, the statistic comparison between Study 1 and Study 2 was not done. The reason of different distribution between study 1 and study 2 would be due to different population. Population of study 2 had included non-frailed elderly persons, otherwise population of study 1 did not included non-frailed elderly persons.

The distribution pattern in Study 2 appeared to be a mixture of non-frail, frail, or disabled subjects; thus, there were two peaks that represented the unhealthy elderly described in Study 1 and non-frail healthy subjects which was similar to the findings described by Hosoya et al.

Based on the findings of the present study, we propose the following:

1. REE can be used as a surrogate marker for unhealthy elderly individuals who are frail or disabled.
2. Discrepancies between REE and dietary energy intake were observed and widely varied among the subjects. These findings suggested that although food intake through the alimentary therapy is important for the elderly, improving the effective absorption of nutrients from the digestive system is imperative.
3. We do not believe that low energy intake is sufficient for the elderly people with low energy expenditures because it is a well-known fact that malnutrition results in a decline in physical power, immunity, and vitality. Therefore, optimal effective dietary energy intake for the elderly with low energy expenditure should be established.
4. It appears to be essential to avoid excessive nutrition intake in comparison with REE, particularly in the elderly who are toward the end of their lifespans.
5. The design of an alimentary therapeutic strategy should be based on the individual measurements for

REE of a patient, if possible.

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Disclosure Statement

There was no conflict of interest that has affected the results of this study. The institutional ethics committee approved this study.

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