Data analysis

Statistical analyses were carried out using SPSS version 17 (SPSS, Chicago, IL, USA). The continuous quantitative comparison of data, such as the cognitive assessment, vital function tests and RIE, was carried out in multiple comparisons using one-way ANOVA with the Bonferroni post-hoc test. Correlation analyses were used for comparison of RIE for each severity of dementia. Additionally, partial correlation coefficients were calculated adjusting for age and sex. The qualitative data, such as the incidence of E-BPSD, were analyzed using the χ^2-test. Differences in RIE between the group of patients with each symptom and the group of patients without each symptom were analyzed using Student's *t*-test. Parameters showing a statistically significant difference were further investigated by multivariate analysis using logistic regression analysis. In this analysis, "RIE = 100%" was assigned a value of 0, whereas "RIE < 100%" was assigned a value of 1, and factors related to a decrease in independence in eating were determined. Statistical significance was defined as $P < 0.05$.

Results

The data for patient age and sex are shown stratified for the severity of dementia (Table 1). The subjects analyzed in the present study were 150 elderly patients with AD (13 men [8.7%], 137 women [91.3%]; mean age, 87.0 ± 7.9 years). There were more women than men, but age showed no sex difference. Stratification by the CDR showed 41 patients with CDR1 (27.3%), 59 with CDR2 (39.3%) and 50 with CDR3 (33.3%).

The results for age, MMSE, vital functions and RIE were stratified for the CDR (CDR1, CDR2 and CDR3) (Table 2). These data show that excluding age, significant decreases in scores were observed as the severity of dementia increased for MMSE score ($P < 0.001$), BI score ($P < 0.001$), VI score ($P < 0.001$) and RIE ($P < 0.001$). The correlation coefficients and partial correlation coefficients between RIE and the other factors were calculated (Table 3). Overall, in the Spearman's test, a strong relationship was observed between RIE and MMSE score ($\rho = 0.519$, $P < 0.001$), BI ($\rho = 0.566$, $P < 0.001$) and VI ($\rho = 0.555$, $P < 0.001$). In contrast, in the stratified analysis for the severity of dementia, strong correlations were found in only CDR3 for the relationship between RIE and MMSE ($\rho = 0.531$, $P < 0.001$), BI ($\rho = 0.517$, $P < 0.001$) and VI ($\rho = 0.518$, $P < 0.001$). After adjustment for covariates, age and sex, RIE had strong associations with MMSE (partial correlation coefficient = 0.485, $P < 0.001$), BI (partial correlation coefficient = 0.421, $P < 0.001$) and VI (partial correlation coefficient = 0.456, $P < 0.001$).

The results of the neurological assessment, the facial and oral motor function test and the observed eating-related BPSD were compared with stratification for the severity of dementia, and relationships with RIE were evaluated (Table 4). The following items were significantly more frequently observed as the severity of dementia increased: "difficulty in rinsing/gargling" ($P < 0.001$), "presence of dysphagia signs (choking when eating, wet hoarseness, and cough and voice change after swallowing)" ($P < 0.001$), "difficulty in beginning a meal" ($P < 0.001$), "difficulty in proper use of utensils" ($P < 0.001$), "difficulty in scooping the proper amount of food" ($P < 0.001$), "difficulty in recognizing the total amount of food provided" ($P < 0.001$), "difficulty in maintaining attention while eating" ($P < 0.001$) and "difficulty in maintaining alertness while eating" ($P < 0.001$). In the evaluation of relationships with RIE, a significant difference in RIE was observed between patients with and without contracture in the CDR1 patients ($P = 0.023$), but not overall or in the other groups separately. A significant difference in RIE was observed between patients with and without difficulty in rinsing/gargling overall ($P < 0.001$) and in CDR2 ($P = 0.009$) separately. However, a statistically significant difference in RIE was observed between patients with and without the presence of dysphagia signs overall ($P = 0.003$) and in CDR3 ($P = 0.026$) separately. RIE was found to be significantly different between patients with and without difficulty in beginning a meal overall ($P < 0.001$) and in CDR2 ($P = 0.045$) and CDR3 ($P = 0.037$) separately. A statistically significant difference in RIE was observed between patients with and without difficulty in proper use of utensils overall ($P < 0.001$) and in CDR3 ($P = 0.008$) separately. Statistically significant differences in RIE were observed between patients with and without difficulty in scooping the proper amount of food overall ($P < 0.001$) and in CDR3 ($P = 0.004$) separately. Although there was a difference overall ($P < 0.001$), there was no significant difference in RIE between patients with and without difficulty in recognizing the total amount of food provided when stratified for the severity of dementia. Significant differences in RIE were observed between patients with and without difficulty in maintaining attention while eating overall ($P < 0.001$) and in CDR3 ($P = 0.046$) separately. Significant differences in RIE were observed between patients with and without difficulty in maintaining alertness while eating overall ($P < 0.001$) and in CDR2 ($P = 0.014$) separately.

To identify factors that hindered independence in eating, logistic regression analysis was carried out for parameters that showed a statistically significant relationship with a decrease in independence in eating with correction for confounding factors (Table 5). A total of nine factors (contracture, difficulty in rinsing/gargling, the presence of dysphagia signs, difficulty in beginning a meal, difficulty in proper use of utensils, difficulty in scooping the proper amount of food, difficulty in

Table 1 Mean age of participants and sex of patient population stratified for severity of dementia

AD	CDR1 (27.3%)			CDR2 (39.3%)			CDR3 (33.3%)			Total population	
	n	%	Age (mean ± SD)	*n*	%	Age (mean ± SD)	*n*	%	Age (mean ± SD)	*n*	Age (mean ± SD)
Males	5	12.2%	82.4 ± 9.1	4	6.8%	85.5 ± 3.3	4	8.0%	87.3 ± 13.0	13	84.7 ± 8.3
Females	36	87.8%	87.6 ± 6.4	55	93.2%	86.9 ± 8.5	46	92.0%	87.4 ± 8.2	137	87.2 ± 7.9
Overall	41	100.0%	87.0 ± 6.9	59	100.0%	86.8 ± 8.3	50	100.0%	87.4 ± 8.3	150	87.0 ± 7.9

AD, Alzheimer's disease; CDR1, Clinical Dementia Rating mild; CDR2, Clinical Dementia Rating moderate; CDR3, Clinical Dementia Rating severe.

recognizing the total amount of food provided, difficulty in maintaining attention while eating, and difficulty in maintaining alertness while eating) were identified by univariate analysis ($P \leq 0.25$). For correction, age, sex and severity of dementia were included, giving a total of 12 independent variables. The results of the analyses identified the following factors hindering independence in eating: difficulty in beginning a meal (odds ratio (OR) = 14.498, 95% confidence intervals (CI) = 2.067–101.690), presence of dysphagia signs (OR = 5.214, CI = 1.031–26.377), and severity of dementia (OR = 4.538, CI = 1.154–17.843).

Discussion

Various methods have been developed for the assessment of E-BPSD in order to provide effective interventions for patients with dementia at mealtime. Major assessment methods include the 11-item Edinburgh Feeding Evaluation in Dementia (EdFED) Questionnaire,[25] the 33-item Feeding Behavior Inventory[13] and the 6-item Eating Behaviour Scale (EBS).[26] These questionnaires focus on the care methods and care needs as perceived from the viewpoint of the care provider, once spoon-feeding has been started.[6] However, few studies have assessed the eating behavior of patients before starting spoon-feeding. "Eating behavior" is defined as an organism's thoughts, actions and intentions to ingest solids or liquids.[27] However, in dementia patients, this eating behavior can be influenced by such changes as altered level of consciousness, attention disorders,[4] initiation disorders,[28] disorientation,[3] decision-making disorders,[26] impairment of executive function,[4] impairment of visuospatial function,[26] upper limb disorders and apraxia including buccofacial apraxia.[29,30] As a result, various E-BPSD can manifest.[12]

These problems involve difficulties in recognizing that the material in front of one is food, planning of what should be transported to the mouth and in what quantity and by what means, and actual execution of that plan. Assessment methods that focus on problems relating to the process of eating at the stage where a patient is still self-feeding have not been developed.[27] The present research was carried out with the objectives of determining the factors affecting independence in eating, elucidating which E-BPSD manifest and at what level of severity of dementia. This can provide basic information that will lead to establishment of effective caregiving methods for dementia patients and will assist them in eating independently as long as possible. Thus, we evaluated independence in eating using objective numerical data and directly observed participants from beginning a meal through its completion in the present study. This observation method was based on FTLT. In addition, we carried out assessments by focusing on the actual condition of the participants, so that we could

Table 2 Comparison of basic data according to level of severity of dementia

	Comparison of each severity of dementia								
	CDR1		CDR2		CDR3		ANOVA	Bonferroni test	
	n	Mean ± SD	*n*	Mean ± SD	*n*	Mean ± SD	*P*-value		*P*-value
Age (years)	38	86.9 ± 6.9	55	86.8 ± 8.3	48	87.4 ± 8.3	0.934		
MMSE	41	18.6 ± 5.6	57	11.3 ± 5.5	47	3.0 ± 4.6	<0.001	CDR1 > CDR2	<0.001
								CDR1 > CDR3	<0.001
								CDR2 > CDR3	<0.001
BI	41	65.1 ± 21.4	59	47.3 ± 24.6	50	15.9 ± 17.1	<0.001	CDR1 > CDR2	<0.001
								CDR1 > CDR3	<0.001
								CDR2 > CDR3	<0.001
VI	41	7.9 ± 1.9	59	6.3 ± 2.4	50	3.2 ± 1.9	<0.001	CDR1 > CDR2	0.001
								CDR1 > CDR3	<0.001
								CDR2 > CDR3	<0.001
RIE	30	99.8 ± 1.2	52	96.9 ± 10.1	42	63.8 ± 39.1	<0.001	CDR1 > CDR3	<0.001
								CDR2 > CDR3	<0.001

Left: Population and mean of score, stratified by level of severity of dementia. Right: Differences as a result of severity were tested by one-way ANOVA with Bonferroni post-hoc test. BI, Barthel Index (score 0–100); CDR1, Clinical Dementia Rating mild; CDR2, Clinical Dementia Rating moderate; CDR3, Clinical Dementia Rating severe; MMSE, Mini-Mental State Examination (score 0–30); RIE, rate of independence in eating (score 0–100); VI: Vitality Index (score 0–10).

Table 3 Simple and partial correlations between basic data and rate of independence in eating

	Spearman's correlation coefficient relative to RIE								Partial corr.	
	Overall		CDR1		CDR2		CDR3		Overall	
	ρ	*P*-value	ρ	*P*-value	ρ	*P*-value	ρ	*P*-value	Partial. corr	*P*-value
Age (years)	−0.127	0.176	0.000	1.000	−0.133	0.366	−0.186	0.251		
MMSE	0.519	<0.001	−0.032	0.865	−0.030	0.837	0.531	<0.001	0.485	<0.001
BI	0.566	<0.001	0.312	0.093	0.201	0.153	0.517	<0.001	0.421	<0.001
VI	0.555	<0.001	0.175	0.354	0.216	0.124	0.518	<0.001	0.456	<0.001

Left: Spearman's test was used to determine Spearman's correlation coefficients relative to rate of independence in eating (RIE; score 0–100). Right: Partial correlation coefficients are adjusted by age and sex. BI, Barthel Index (score 0–100); CDR1, Clinical Dementia Rating mild; CDR2, Clinical Dementia Rating moderate; CDR3, Clinical Dementia Rating severe; MMSE, Mini-Mental State Examination (score 0–30); ρ, Spearman's correlation coefficient; Partial.corr, partial correlation coefficient; VI, Vitality Index (score 0–10).

understand the degree of E-BPSD as a function of the severity of dementia, and also observe and understand the functional disorders and environmental factors that might cause E-BPSD.

Because AD is a degenerative disease of the brain, it shows a typical pattern that is comparable to degenerative dementia.[31] Therefore, if AD worsens, the impairment can affect visuospatial cognition, the coordination and speed of functions, and planning the action for moving food to the mouth, which involves knowing the "what", "how much" and "how to" of eating behavior.[32,33]

Independence in eating, as assessed by RIE, was maintained in CDR2 patients, but significantly decreased in CDR3 patients. It is suggested that even when dementia has progressed, patients maintain their interest in eating until cognition becomes severely impaired. In the present study, correlations between vital functions and RIE were established only in CDR3. According to a comparison of average values shown in Table 2, there is little change in RIE, even though a clear decline in BI and VI is shown in CDR1 and CDR2. Therefore, it can be considered that the decline in BI and VI is the result of the decline in all vital functions, except eating ability in CDR1 and CDR2. Furthermore, this result suggests that vital functions assessed by BI and VI decline earlier than eating ability. The data from specific groups of AD in the present study are in agreement with previous reports that referred to empirically supported strategies for feeding patients with dementia.[3,8,12]

Our findings showed that RIE decreased as the severity of dementia increased, and that E-BPSD and the presence of dysphagia signs were significantly related with RIE in general over the range of moderate to severe

Table 4 Comparisons of assessments according to such items as contracture, rinsing/gargling, exhibition of signs of dysphagia, eating-related behavioral and psychological symptom of dementia and oral medications, and differences in rate of independence in eating

	Comparison of each severity of dementia							Difference in RIE with or without each symptom (*t*-test)			
	CDR1		CDR2		CDR3		Comparison of level of severity (χ^2)	Overall	CDR1	CDR2	CDR3
	Applicable patients (%)	Overall (*n*)	Applicable patients (%)	Overall (*n*)	Applicable patients (%)	Overall (*n*)	*P*-value	*P*-value	*P*-value	*P*-value	*P*-value
Neurological examination											
Contracture	14.6%	41	1.7%	58	39.6%	48	<0.001	0.092	0.023	0.763	0.895
Facial and oral motor function test											
Difficulty in rinsing/gargling	2.4%	41	8.5%	59	49.0%	49	<0.001	<0.001	0.856	0.009	0.112
Eating-related BPSD											
Presence of dysphagia signs	12.8%	39	23.7%	59	51.0%	49	<0.001	0.003	0.697	0.805	0.026
Difficulty in beginning a meal	2.6%	39	27.1%	59	75.5%	49	<0.001	<0.001		0.045	0.037
Difficulty in proper use of utensils	5.1%	39	18.6%	59	69.4%	49	<0.001	<0.001	0.791	0.064	0.008
Difficulty in scooping the proper amount of food	2.6%	39	27.1%	59	71.4%	49	<0.001	<0.001	0.854	0.081	0.004
Difficulty in recognizing the total amount of food provided	7.7%	39	27.1%	59	71.4%	49	<0.001	<0.001	0.791	0.229	0.119
Difficulty in maintaining attention while eating	7.7%	39	37.3%	59	83.7%	49	<0.001	<0.001	0.741	0.151	0.046
Difficulty in maintaining alertness while eating	0.0%	39	22.0%	59	63.3%	49	<0.001	<0.001		0.014	0.262

Left: Applicable patients in each level of severity of dementia. Middle: Comparison of the severity of dementia was performed using the χ^2-test. Right: Difference of rate of independence in eating (RIE) between patients with and without each symptom using Student's *t*-test. BPSD, behavioral and psychological symptom of dementia; CDR1, Clinical Dementia Rating mild; CDR2, Clinical Dementia Rating moderate; CDR3, Clinical Dementia Rating severe;

Table 5 Factors that affect hindering independence in eating confirmed using logistic regression analysis

Factor		Univariate			Multivariate		
		OR	95% CI	*P*-value	OR	95% CI	*P*-value
Age	(Continuous quantity)	1.029	(0.975–1.085)	0.304	0.999	(0.908–1.099)	0.977
Sex	(F = 0, M = 1)	2.222	(0.526–9.385)	0.277	0.375	(0.023–6.017)	0.489
Severity of dementia (CDR)	(mild = 1, moderate = 2, severe = 3)	8.801	(3.980–19.463)	<0.001	4.538	(1.154–17.843)	0.030
Contracture	(no = 0, yes = 1)	2.607	(1.016–6.691)	0.046	0.432	(0.071–2.630)	0.363
Difficulty in rinsing/gargling	(easy = 0, difficult = 1)	11.611	(4.117–32.750)	<0.001	2.023	(0.274–14.937)	0.490
Presence of dysphagia signs	(no = 0, yes = 1)	6.020	(2.600–13.935)	<0.001	5.214	(1.031–26.377)	0.046
Difficulty in beginning a meal	(easy = 0, difficult = 1)	22.531	(8.293–61.211)	<0.001	14.498	(2.067–101.690)	0.007
Difficulty in proper use of utensils	(easy = 0, difficult = 1)	11.089	(4.553–27.009)	<0.001	0.375	(0.033–4.228)	0.428
Difficulty in scooping the proper amount of food	(easy = 0, difficult = 1)	19.098	(7.265–50.205)	<0.001	6.170	(0.555–68.586)	0.139
Difficulty in recognizing the total amount of food	(easy = 0, difficult = 1)	9.192	(3.846–21.966)	<0.001	0.111	(0.010–1.272)	0.077
Difficulty in maintaining attention while eating	(easy = 0, difficult = 1)	22.826	(7.295–71.421)	<0.001	3.538	(0.409–30.627)	0.251
Difficulty in maintaining alertness while eating	(easy = 0, difficult = 1)	10.769	(4.419–26.247)	<0.001	0.737	(0.149–3.644)	0.709

"RIE = 100%" was assigned a value of 0, whereas "0–99.9%" was assigned a value of 1. Left: Univariate analysis using logistic regression analysis. Right: Multivariate analysis using logistic regression analysis. CDR, Clinical Dementia Rating; RIE, rate of independence in eating (score 0–100).

dementia. These findings are not considered to be in agreement with those of earlier reports.[34] The decrease in RIE that occurs after dementia reaches the CDR3 stage can be considered to be related to the disorientation, agnosia, and executive function disorder, disordered planning and correction of behavior that become marked in severe dementia.[26] Although RIE showed a particularly marked decrease in CDR3 patients, its mean value of 63.8 ± 39.1% was higher than predicted. This is in agreement with a report that procedural memory and motor learning are preserved even when memory is severely impaired.[35]

E-BPSD parameters in the present study showed statistically significant correlations with RIE. It can be surmised that these relationships are influenced by the manifestation of attention disorders,[35] executive function disorders and apraxia as a result of the deterioration of dementia. In particular, difficulty in beginning a meal was also significantly related to RIE. This finding strongly suggests that disorders such as apraxia are also involved,[36] in addition to attention disorders and difficulty in maintaining alertness.

The reasons for difficulty in assisting with eating in AD can include various factors impairing independence in eating. In the present study, the application of logistic regression analysis showed that difficulty in beginning a meal, presence of dysphagia signs and the severity of dementia are factors that strongly hinder independence in eating in AD. This report is the first to objectively identify factors that affect the decrease in independence in eating in AD patients as a targeted population.

In agreement with an earlier report, the severity of dementia was a factor strongly affecting the independence in eating as a result of deterioration of dementia.[13]

In addition, we found that the presence of dysphagia signs significantly contributed to the decrease in independence in eating. This is in agreement with some clinical reports that showed that dysphagia is the most common factor in advanced AD.[3,8,12] At the time when dysphagia becomes evident in AD, worsening of the severity of dementia, impairment of the basic physical functions,[33] such as the defense reflexes,[4] and pseudobulbar paralysis[37] are usually present. In addition, buccofacial apraxia[6] and generalized cognitive impairment are prominent. That is, it can be surmised that as a result of these various dysfunctions, the patient is already in a state where the series of actions necessary for eating cannot be carried out. Furthermore, special measures are commonly instituted for dysphagia in AD after it has become severe, including changing the texture of meals and adjusting the patient's posture.[4] However, after a patient has actually developed severe dementia, he or she is often unable to follow the directions required to carry out a compensatory swallow maneuver or a specific therapeutic rehabilitative exercise.[4] Because worsening of the core symptoms of AD is inevitable, it has

been considered important to implement professional training while the dementia is still mild, thereby maintaining the swallowing function and minimizing the dysfunction when the dementia becomes severe.[12]

Finally, the application of logistic regression analysis showed that difficulty in beginning a meal was an even stronger risk factor for hindrance of eating independence than worsening of the severity of dementia in AD. Many reports have investigated the background to decreased independence in eating in AD.[12,13,32,37,38] Even when the appetite and the functions of eating are preserved, the following points requiring attention for promotion of independence in eating in AD have been reported: loss of cues to begin eating and restart eating, such as attention disorder, disorientation, agnosia, ideational apraxia,[29] conceptual apraxia[30] and executive function disorder.[38] When patients do not start eating by themselves, they are often found to be anorexic or akinetic, and spoon-feeding is often initiated to ensure sufficient nutritional intake.[4] Once spoon-feeding is started, patients tend to become dependent on assistance, which can explain the rapid loss of independence. Furthermore, it becomes easier for such patients to develop further eating difficulties.[6] Accordingly, it has been pointed out that, with the deterioration of dementia, features develop, such as apathy, in regard to loss of appetite and food[39] and emotions.[28]

Even when a loss of cues to begin eating and restart eating means that the patient is unable to start eating, it is possible to aid the patient with such cues or give assistance in the form of adjusting the quality and amount of environmental stimuli that will help prevent confusion and interruption of eating.[38] It was thus reported that by such means it is possible to maintain, even partially, each patient's eating behavior.[12] This sort of assistance involves interactions in terms of the quality, amount and timing of environmental intervention, including the care provider.[6] Our findings showed that not only the effects of the deterioration of dementia, but also those arising from the eating environment strongly influence the decrease in independence in eating seen in AD. In fact, in today's actual caregiving setting, assessments and responses are left in the hands of the individual care providers, and trial-and-error approaches are attempted amidst confusion.[4]

AD is a progressive disease, and inhibition of the progression of its core symptoms is difficult. The following steps can be considered important in relation to AD. Changes in the status of cognitive functions, vital functions and swallowing function that accompany each stage of dementia should be accurately comprehended. The E-BPSD that accompany the deterioration of dementia should be predicted from the stage of mild dementia, when there is still no marked manifestation of dysphagia, and suitable countermeasures should be identified. Finally, caregivers should implement interventions that have predictability, such as the introduction of a program for maintaining swallowing function.

Maintaining eating independence in AD patients can be facilitated by identifying factors that interfere with beginning a meal by providing multidisciplinary care, eliminating environmental factors and providing assistance that promotes beginning a meal. We consider the objectively generated findings of the present study to represent basic data that will prove useful to all clinicians and care providers who are involved in providing assistance to elderly patients with AD.

The present study was primarily a survey of the actual status of eating behavior in elderly patients with AD based on observational assessments and the use of a questionnaire. Accordingly, we carried out no validation with regard to the effectiveness of providing assistance. In the future, it will be necessary to carry out prospective cohort studies that monitor the course of dementia and to undertake intervention studies. Detailed investigations aimed at establishing effective methods for assisting in the preservation of independence in eating in elderly patients with dementia are needed.

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Disclosure statement

The authors declare no conflict of interest.

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