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Eating problems in people with dementia with Lewy bodies: Associations with various symptoms and the physician's understanding

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ABSTRACT

Objectives: Eating problems frequently occur in people with dementia with Lewy bodies (DLB), but few studies have investigated the clinical background of this phenomenon. This study examined the relationship between eating problems and various symptoms of DLB and the relation between the treatment needs for DLB people with eating problems and the understanding of their eating problems by caregivers and physicians.

Design, measurements, and participants: This was a subanalysis of a cross-sectional, questionnaire-based survey study. Two hundred sixty-one subjects with DLB were divided into subjects with or without eating problems. Logistic or linear regression analysis was used to investigate the factors influencing eating problems. The treatment needs of DLB people for their eating problems and the understanding of these needs by caregivers and physicians were calculated as participant–caregiver and participant–physician kappa coefficient.

Results: Of the 261 participants, 27% suffered from eating problems. The presence of eating problems in participants with DLB was related to depression ($p = 0.01$, OR : 2.19, 95% CI: 1.23–3.91) and apathy ($p = 0.01$, OR 2.15, 95% CI: 1.20–3.87), while the worsening of eating problems was related to dysphagia ($\beta = 0.24$, $p = 0.03$), apathy ($\beta = 0.23$, $p = 0.05$), and nighttime behavior ($\beta = 0.24$, $p = 0.04$). The participant–physician kappa coefficient for physician understanding of constipation, weight loss, dysphagia, weight gain, and increase in appetite was significantly lower than the corresponding participant–caregiver kappa coefficient (p-value of five symptoms < 0.01).

Conclusions: Physicians need to pay more attention to eating problems and their neuropsychiatric background in the long-term support and management of DLB subjects.

Key words: dementia with Lewy bodies, eating problems, neuropsychiatric symptom, physician's understanding

Introduction

Lewy body dementia consists of dementia with Lewy bodies (DLB) and Parkinson's disease with dementia and is the second most common degenerative dementia in old age after Alzheimer's disease (AD) (Kane *et al.*, 2018; Vann Jones & O'Brien, 2014). In addition to progressive cognitive impairment, DLB is characterized by various clinical manifestations, including visual hallucinations, depression, and other neuropsychiatric problems, rapid eye movement sleep behavior disorder, parkinsonism, and autonomic dysfunction (McKeith *et al.*, 2017), and they are often affected by multiple symptoms at the same time (Fujishiro *et al.*, 2013).

Eating problems are likely to occur in people with DLB because of their parkinsonism, autonomic dysfunction, fluctuations in cognition, and neuropsychiatric symptoms (Shinagawa *et al.*, 2009). As these eating problems have to be managed daily, they become a huge burden on the subjects' caregivers, which could lead to a diminished quality of life (QOL) for the subjects (Shinagawa *et al.*, 2015). These eating problems sometimes disrupt

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home caring, become a trigger for institutionalization, and can even become a major issue within a nursing care facility. However, physicians' understanding of eating problems in people with DLB is often insufficient (Hashimoto *et al.*, 2022). The nutrition-related care and treatment needs of people with DLB may differ from the physician's understanding. Improved communication with caregivers is needed for physicians to accurately evaluate the eating problems of DLB and its clinical background, with the ultimate goal of improving the QOL of both DLB subjects and caregivers.

Until now, only a few systematic studies have investigated the clinical background of eating problems in people with DLB. The authors previously conducted a study on a relatively small sample of people with DLB and AD and found that the people with DLB had higher problem scores for many eating-related domains than those with AD, and that the severity of dementia or Parkinsonism was not the only determinant (Shinagawa *et al.*, 2009). However, the effect of each of multiple possible symptoms in DLB, especially the effect of neuropsychiatric problems including hallucinations, apathy, and depression, which are known to be common in DLB subjects with eating problems, were not clear from that small sample study. It is well known that in DLB, more diverse and severe neuropsychiatric symptoms appear from an early stage than in other major dementias (Hashimoto *et al.*, 2015), but little is known about the effects of these symptoms on eating problems. Although neuropsychiatric symptoms are important symptom in people with DLB that has a significant impact on the course of the disease and even plays a role in their prognosis (Mueller *et al.*, 2017), it is often underestimated. Its pharmacologic management is limited, and its association with eating problems has rarely been investigated.

Hence, the aim of the present study was (1) to reveal the relationship between eating problems and each of multiple possible symptoms common in DLB subjects including neuropsychiatric problems and (2) to compare the caregiver understanding with the physician understanding of the treatment needs for eating problems in DLB subjects.

Methods

Study design and participants

Details of the initial study design have been reported previously (Hashimoto *et al.*, 2022; Toya *et al.*, 2023). This was a multicenter, cross-sectional, observational survey study that included participants with DLB, their caregivers, and their attending physicians as study participants. This study was conducted from September 2020 to July 2021 and included 35 Japanese facilities with DLB specialists as the attending physician. The parent study aimed to examine the treatment needs of participants with DLB and their caregivers and the extent to which the attending physicians understand these treatment needs, to develop future treatment strategies. That study also aimed to examine what factors contribute to the lack of understanding of the attending physicians regarding the treatment needs of participants with DLB and their caregivers.

The inclusion criteria for participants with DLB were being $\geq$ 50 years of age with a diagnosis of probable DLB and attending an outpatient clinic. The diagnosis of probable DLB followed the DLB diagnosis criteria 2017 (McKeith *et al.*, 2017). Subjects with Parkinson's disease with dementia and subjects who were deemed by the physicians to be inappropriate for the survey study were excluded. The inclusion criteria for caregivers were being $\geq$ 20 years of age and the primary caregiver of the subjects. The inclusion criteria for the attending physicians were that they not only cared for the subjects in question but were also experts in DLB treatment in Japan, defined as previously reported (Hashimoto *et al.*, 2022).

Assessments

Participants were evaluated using the Japanese version of the Mini-Mental State Examination (MMSE-J) for cognitive function (Sugishita *et al.*, 2018) and Movement Disorder Society-Unified Parkinson's Disease Rating Scale (MDS-UPDRS) Parts II for ADL and III for parkinsonism (Goetz *et al.*, 2008). Caregivers were asked about the behavioral and psychological symptoms of dementia (BPSD) and cognitive fluctuation using the NPI-12 (Cummings *et al.*, 1994) and the cognitive fluctuation inventory (CFI) (Hashimoto *et al.*, 2014), respectively. Previous studies have emphasized the symptomatic variety and heterogeneity of neuropsychiatric symptoms in DLB during disease progression (Mueller *et al.*, 2017). Thus, the classification of individual neuropsychiatric symptoms into subgroups is necessitated to allow for clinicians to target distinct clusters in their planning of treatments; doing so may lead to the reduction of caregivers' burden. It is also crucial to elucidate the neurobiological mechanisms underlying heterogeneous neuropsychiatric symptoms by specifically examining targeted clusters.

In addition, a shortened Japanese version of the Zarit Caregiver Burden Interview (J-ZBI_8) consisting of eight questions was used to assess caregiver burden (Zarit *et al.*, 1980).

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Factors associated with eating problems

In this study, the NPI-12 subscore for appetite/eating behaviors was used as an indicator of eating problems. Subjects with at least 1 point in NPI-12 appetite/eating behaviors were defined as having an eating problem. As various factors which might be associated with eating problems, the following 12 factors were selected and evaluated: age, gender, MMSE-J total score, MDS-UPDRS Part III total score, Part II total score, NPI-11 score (scores except appetite/eating behaviors), presence of constipation, presence of dysphagia, J-ZBI_8 total score, CFI, presence of antipsychotic intervention, and presence of antiparkinsonian drugs.

Caregiver and physician understanding of the treatment needs of participants with eating problems

Apart from the NPI-12 appetite/eating behaviors subscore, in order to compare the understanding of caregivers and physicians in regard to the treatment needs of their participants with eating problems, we also administered a questionnaire to participants, caregivers, and physicians. For this purpose, we preselected 52 symptoms that are frequent and clinically important in DLB (Hashimoto *et al.*, 2022). Among the 52 symptoms, 9 items, i.e., constipation, dysphagia, loss of appetite, increase in appetite, weight loss, weight gain, unbalanced diet, eating non-edible things, and food refusal were selected as eating-related symptoms.

Similarly, prompts on the questionnaire for caregivers or physicians included "Please select only one symptom that currently causes your patient the most distress" and "Please select all of the patient's other symptom that currently causes your patient the distress." The understanding by caregivers or physicians of their participants' treatment needs for an eating problem was quantified by the answers on these two items among all participants with that particular eating problem and examined as the participant–caregiver and participant–physician kappa coefficient. In addition, for only participants who feel distress every 9 items, the concordance rate of caregivers and physicians for them was also examined.

Statistical analysis

Summary statistics are calculated as the mean ± standard deviation (SD) for continuous scales, and frequencies and percentages were calculated for the nominal measures. Comparisons between groups with and without eating problems were made by unpaired *t*-test or Fisher's exact test.

In order to search for other neuropsychiatric symptoms associated with eating problems, principal component analysis was performed using the Promax procedure with Kaiser's normalization and subscores of the NPI-12. A primary loading score of at least 0.50 for the post-rotation item was the criterion for inclusion or exclusion of each component.

Logistic or linear regression analysis was used to investigate the factors influencing eating problems. First, in order to examine factors contributing to the presence of eating problems, the presence or absence of eating problems was used as the dependent variable in logistic analysis. Only factors that were significantly associated with the presence of eating problems in the univariable analysis were entered into the multivariable analysis. If NPI-11 remained a significant factor, univariable analyses were conducted again for the NPI-11 subitems, and multivariable models were again created including the NPI-11 subitems that were significant. After the multivariable model was created, stepwise methods were used for analyses.

Next, factors contributing to the deterioration of eating problems were examined. A linear regression analysis was conducted using the NPI-eating behavior score as the dependent variable. Univariable and multivariable modeling was performed as in the logistic regression analysis described above.

Regarding the understanding by the caregiver or physician of the eating problems of their participants, comparisons of participants–caregiver and participants–physician kappa coefficient were compared, and marginal homogeneity was assessed by the McNemar's test was conducted. Furthermore, for only participants who feel distress every 9 items, the concordance rate of caregivers and physicians for them were compared by McNemar's test.

All statistical significance tests in this study were two sided with a significance level at 0.05, and all analyses were performed using SAS ver. 9.4 (SAS Institute Inc., Cary, NC). Missing data were excluded from the analysis on a missing item basis. In the multivariable analysis, if a variable with missing data was included in the analysis model, it was excluded on a case-by-case basis.

Ethical considerations

This prespecified additional analysis was conducted in compliance with the ethical principles based on the Declaration of Helsinki (revised in 2013), the Ethical Guidelines for Medical and Health Research Involving Human Subjects (partially revised in 2017), and the research protocol. The study was initially approved by the Ethical Review Board for Observational Research of Osaka University Hospital. In addition, the study was conducted after approval by the respective Ethical Review Committees of each study site. A summary of the

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main study was registered and published in the UMIN Clinical Trials Registry before implementation (UMIN ID: UMIN000041844).

Written informed consent was obtained from participants and their caregivers. Physicians consented to participate in the study via the Internet.

Results

Participant characteristics

Of 272 pairs of participants and caregivers who consented to participate in this study, 8 pairs who did not submit questionnaires, 1 pair who only provided consent, and 2 pairs who did not complete NPI-12 were excluded, resulting in 261 pairs being analyzed. Among the 261 participants, 71 (27.2%) showed some kind of eating problem, with the NPI eating problem domain scoring 1 point or more. The remaining 190 were determined to have no prominent eating problems.

Table 1 shows the background characteristics of participants with and without eating problems. There were no significant differences between the two groups in sex, age, MDS-UPDRS Part III score, or MDS-UPDRS Part II score. There were no significant differences between the two groups in the presence or absence of dysphagia, constipation, antipsychotic use, or anti-parkinsonism use. Significant differences were found in the MMSE score (effect size [ES]: 0.32), the total NPI score (ES: 0.87), the 11-item NPI score (ES: 0.63) excluding eating behavior, the CFI score (ES: 0.35), and the J-ZBI score (ES: 0.41). Lower MMSE scores and higher NPI, CFI, and J-ZBI scores were found in the group with eating disorders.

Principal component analysis of neuropsychiatric symptoms in DLB

In the principal component analysis, three optimal clusters were selected using the eigenvalue criteria (Table 2). The first cluster comprised symptoms of psychosis syndrome, including delusions, hallucinations, and aberrant motor behavior. The second cluster comprised symptoms of agitation syndrome, including agitation/aggression, irritability, and euphoria. The third cluster identified symptoms of depressive syndrome, including eating problems, depression, euphoria, and apathy. Note that here, eating problems in participants with DLB were classified into the same factor with depression and apathy. Anxiety, disinhibition, and sleep/nighttime behavior were not included in any of the clusters.

Factors associated with the presence of eating problems in DLB

Univariable regression analysis revealed that the J-ZBI_8 score ($\geq$ 7 as median) ($p = 0.01$; odds ratio [OR]: 2.13; 95%CI: 1.21–3.75), CFI score ($\geq$ 1 as median) ($p = 0.03$; OR: 1.92; 95% CI: 1.08–3.40), and NPI-11 score ($\geq$ 11 as median) ($p < 0.01$; OR: 2.93; 95% CI: 1.64–5.24) were significantly associated with the presence of eating problems in DLB. No other factors were associated with the presence of eating problems in DLB. The association with high NPI-11 score ($p = 0.02$; OR: 2.28; 95% CI: 1.15–4.50) was the only factor that persisted in multivariable analysis.

Since the NPI-11 was extracted, a univariable analysis of the NPI-11 was conducted and revealed that all NPI subitems except anxiety, disinhibition, and abnormal behavior were significant factors. A new model was created using J-ZBI_8, CFI score, hallucinations, delusions, agitation, depression, euphoria, irritability and nighttime behavior, and then multivariable analysis was conducted. The results of the multivariable analysis according to the stepwise method showed that depression ($p = 0.01$; OR: 2.19; 95% CI: 1.23–3.91), euphoria ($p = 0.01$; OR: 2.91; 95% CI: 1.29–6.58), and apathy ($p = 0.01$; OR: 2.15; 95% CI: 1.20–3.87) were significantly associated with the presence of eating problems.

Since euphoria belonged to a different cluster in the PCA analysis, we examined the subclassification of eating problems by the presence or absence of euphoria. Among the 71 participants with eating problems, 15 had euphoria and 56 had no euphoria. Of the euphoria group, 46.7% (7/15) showed an appetite increase, compared to 28.6% (16/56) of the no-euphoria group.

Factors associated with high scores of eating problems in DLB

The factors for aggravation of eating behavior disorder that were significant in the univariable analysis were high NPI-11, presence of dysphagia, and high J-ZBI_8 score. Multivariable regression analysis revealed that only high NPI-11 score was significantly associated with an increase in the eating problems score in DLB (standardized regression coefficients [β] = 0.29, $p = 0.02$). No other factors were associated with increased eating problem scores in DLB.

Since NPI-11 was extracted, a univariable analysis was conducted on the NPI-11 subscores. Apathy, abnormal behavior, and nighttime behavior were extracted as significant items. A new model was then created using dysphagia, J-ZBI_8, apathy,

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Table 1. Background characteristics of participants with and without eating problems

	NO EATING PROBLEMS	WITH EATING PROBLEMS		
	$N = 190$	$N = 71$	*P*-VALUE	EFFECT SIZE
Sex (M / F)	91 / 99	36 / 35	0.78[a]	$\Phi = 0.03$
Age	79.3 ± 6.9; 80 [58, 94]	79.1 ± 6.2; 80 [63, 91]	0.83[b]	$d = 0.03$
MMSE	21.5 ± 5.5; 23 [0, 30]	19.6 ± 6.3; 21 [5, 30]	0.02[b]	$d = 0.32$
MDS-UPDRS Part III	23.3 ± 19.8; 17 [0, 99]	24.8 ± 22.5; 22 [0, 97]	0.58[b]	$d = 0.07$
MDS-UPDRS Part II	11.0 ± 10.9; 8 [0, 50]	12.0 ± 10.5; 10 [0, 46]	0.53[b]	$d = 0.09$
NPI-12	11.9 ± 12.6; 8.5 [0, 70]	26.8 ± 20.7; 23.0 [1, 98]	<0.01[b]	$d = 0.87$
NPI-11	11.9 ± 12.6; 8.5 [0, 70]	22.3 ± 19.6; 19.0 [0, 95]	<0.01[b]	$d = 0.63$
CFI	2.0 ± 2.8; 1.0 [0, 12]	3.1 ± 3.4; 2.0 [0, 12]	0.01[b]	$d = 0.35$
J-ZBI	7.6 ± 6.2; 6 [0, 25]	10.2 ± 6.5; 9 [0, 25]	<0.01[b]	$d = 0.41$
with Dysphagia	11 (5.8%)	6 (8.5%)	0.41[a]	$\Phi = 0.05$
with Constipation	59 (31.1%)	20 (28.2%)	0.76[a]	$\Phi = 0.03$
Use of antipsychotics	27 (14.2%)	16 (22.5%)	0.13[a]	$\Phi = 0.10$
Use of antiparkinsonian	78 (41.1%)	26 (36.6%)	0.57[a]	$\Phi = 0.04$

P-value: a, unpaired t-test; b, Fisher's exact test, Mean ± SD; median (range) were expressed.

Table 2. Principal component analysis of neuropsychiatric symptoms in DLB

	FACTOR 1	FACTOR 2	FACTOR 3
NPI-Hallucinations	0.818	− 0.239	0.090
NPI-Delusions	0.783	0.052	− 0.044
NPI-Aberrant motor behavior	0.720	0.065	− 0.05
NPI-Anxiety	0.445	0.259	− 0.030
NPI-Disinhibition	0.337	0.314	− 0.162
NPI-Irritability	− 0.012	0.802	0.079
NPI-Agitation	0.248	0.627	0.052
NPI-Euphoria	− 0.127	0.611	0.010
NPI-Appetite/eating disorder	− 0.068	− 0.069	0.822
NPI-Depression	− 0.195	0.228	0.625
NPI-Apathy	0.186	0.031	0.536
NPI-Sleep/nighttime behavior	0.371	− 0.083	0.466

abnormal behavior, and nighttime behavior, and a multivariable analysis was conducted. The stepwise method revealed that presence of dysphagia (β = 0.24, $p = 0.03$), nighttime behavior (β = 0.24, $p = 0.04$), and apathy (β = 0.23, $p = 0.05$) were significant items.

Caregiver and physician understanding of the treatment needs of participants with eating problems

Apart from the NPI-12 appetite/eating behaviors subscore, 9 items were selected as eating-related symptoms to compare awareness of the treatment needs of participants by caregivers and physicians. Among them, constipation was the most distressing symptom for participants, followed by weight loss, loss of appetite, and dysphagia (Tables 3 and 4). The participant–physician kappa coefficient for physician understanding of constipation, weight loss, dysphagia, weight gain, and increase in appetite were significantly lower than the corresponding participant–caregiver them (p-value of five symptoms < 0.01). And constipation, weight loss, weight gain, and increase of appetite were significant discrepancy according to the McNemar's test of the participant–physician (Table 3).

For only participants who feel distress every 9 items, the participant–caregiver concordance rates for constipation, weight loss, dysphagia, weight gain, and increase in appetite were above 50%. On the other hand, the participant–physician concordance rates were less than 30% for all eating problems. The participant–physician concordance rates for

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Table 3. Comparison understanding of caregiver and physician for participants eating problem

	CAREGIVER ANSWER	PARTICIPANT ANSWER		THE PARTICIPANT–CAREGIVER	PHYSICIAN ANSWER	PARTICIPANT ANSWER		THE PARTICIPANT-PHYSICIAN	*P*-VALUE
		YES	NO			YES	NO		
Constipation	Yes	64	29	Kappa = 0.58	Yes	25	22	Kappa = 0.19	<0.01
	No	22	146	McNemar = 0.40	No	61	153	McNemar<0.01	
Weight loss	Yes	15	8	Kappa = 0.57	Yes	2	6	Kappa = 0.07	<0.01
	No	11	227	McNemar = 0.65	No	24	229	McNemar = 0.01	
Loss of appetite	Yes	12	13	Kappa = 0.43	Yes	5	10	Kappa = 0.19	0.08
	No	13	223	McNemar = 1.00	No	20	226	McNemar = 0.10	
Dysphagia	Yes	9	8	Kappa = 0.48	Yes	1	7	Kappa = 0.04	<0.01
	No	9	235	McNemar = 1.00	No	17	236	McNemar = 0.07	
Weight gain	Yes	10	5	Kappa = 0.60	Yes	0	1	Kappa = -0.01	<0.01
	No	7	239	McNemar = 0.77	No	17	243	McNemar<0.01	
Increase of appetite	Yes	9	4	Kappa = 0.65	Yes	1	2	Kappa = 0.10	<0.01
	No	5	243	McNemar = 1.00	No	13	245	McNemar = 0.01	
Unbalanced diet	Yes	2	3	Kappa = 0.39	Yes	0	0	Kappa = 0.00	0.10
	No	3	253	McNemar = 1.00	No	5	356	McNemar = N.C.	
Food refusal	Yes	1	2	Kappa = 0.28	Yes	0	0	Kappa = 0.00	0.44
	No	3	255	McNemar = 1.00	No	4	257	McNemar = N.C.	
Eating nonedible things	Yes	0	1	Kappa = 0.00	Yes	0	0	Kappa = 0.00	1.00
	No	1	259	McNemar = 1.00	No	1	260	McNemar = N.C.	

P-value: The participant–caregiver kappa coefficient vs the participant–physician kappa coefficient.
Kappa, Kappa coefficient; McNemar, P-value of McNemar's test; N.C., not calculated.

Table 4. Treatment needs of only participants who feel distress each eating problems and understanding of their caregivers and physicians

	PARTICIPANTS FEEL DISTRESS *N* (%)	AMONG THEM, CAREGIVER'S UNDERSTANDING (%)	AMONG THEM, PHYSICIAN'S UNDERSTANDING (%)	*P*-VALUE (CAREGIVER-PHYSICIANS)
Constipation	86 (32.7)	74.4	29.1	<0.01
Weight loss	26 (9.9)	57.7	7.7	<0.01
Loss of appetite	25 (9.5	48.0	20.0	0.07
Dysphagia	18 (6.8)	50.0	5.6	<0.01
Weight gain	17 (6.5)	58.8	0	<0.01
Increase in appetite	14 (5.3)	64.3	7.1	<0.01
Unbalanced diet	5 (1.9)	40.0	0	0.50
Food refusal	4 (1.5)	25.0	0	1.00
Eating nonedible things	1 (0.4)	0.00	0	N.C.

constipation, weight loss, dysphagia, weight gain, and increase in appetite were significantly lower than the corresponding participant–caregiver rates (p-values of all five symptoms < 0.01), indicating that physicians had a poor understanding of their participants' eating problems (Table 4).

Discussion

This is the first detailed examination of the various factors associated with the eating problems of people with DLB in a large number of cases with consideration for the concordance between physician and participant understanding of the eating problems. The results of this study showed that 27% of participants with DLB suffered from eating problems. The presence of eating problems in participants with DLB was related to depression and apathy, while the worsening of eating problems was related to dysphagia, apathy, and nighttime behavior. Although their number was few, there were cases with appetite increase, which seemed to be related with expressions of euphoria. Furthermore, understanding of the participants' constipation, weight loss, dysphagia, weight gain, and increase in appetite was significantly lower among the physicians than the caregivers.

In this sample, 27% of the participants had eating problems. Although this percentage may not seem large, it should be remembered that the sample comprised subjects with relatively mild disease, whose mean MMSE-J score was 20.9; in this sense, the percentage was not small. As the disease progresses, the percentage of people with eating problems may increase. This result is consistent with previous report that nutritional status was worse in people with DLB than in those with AD (Koyama *et al.*, 2016).

The authors have previously reported on a relatively small sample of subjects with DLB and found that the UPDRS score significantly affected the scores for "difficulty in swallowing foods," "taking a long time to swallow," and "needs watching or help," whereas the NPI score affected the score for "loss of appetite," and the scores for UPDRS, NPI, and the Clinical Dementia Rating significantly affected the score for "difficulty in swallowing liquids" (Hughes *et al.*, 1982; Shinagawa *et al.*, 2009). On the other hand, neuropsychiatric symptoms mainly affected eating problems in this study. There may be several reasons for this difference. First, the mean MMSE-J score was 20.9 in this study and 18.0 in the previous study, suggesting that subjects with relatively milder disease were included in this study. As the disease progresses, the impact of parkinsonism is expected to be greater. More than 80 % of people with Parkinson's disease (PD) are reported to develop dysphagia during the course of their disease (Schindler *et al.*, 2021; Suttrup & Warnecke, 2016).

Depression and apathy, which were in the same cluster in the principal component analysis, were associated with the presence of eating problems in DLB with similar effects (OR of about 2.2). It is often reported and well known that depression and apathy are frequently observed in people with DLB (Auning *et al.*, 2011; Chiu *et al.*, 2017; Fujishiro *et al.*, 2013; Hashimoto *et al.*, 2015; Kazui *et al.*, 2016; McKeith *et al.*, 2017; Schwertner *et al.*, 2022). The presence of depression in people with AD has been reported to cause decreased appetite (Suma *et al.*, 2018). The presence of apathy also contributes to decreased appetite, and reports on this subject are also not extensive. A similar mechanism seems to occur in people with DLB, and the impact is rather strong.

On the other hand, it is interesting that euphoria may be related to the appetite increase of people with

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DLB. Although decreased appetite is common in DLB, it is sometimes experienced that people with DLB with decreased appetite develop an increased appetite over time. The present results may support this observation, possibly associated with underlying DLB specific mood fluctuations. Further studies are needed on this point. Also, it is interesting to note that nighttime behavior including REM sleep behavior disorder and sleep–awake rhythm disorder exacerbated the worsening of eating problems in DLB (Chan *et al.*, 2018). The mechanism of this association is not yet clear, but disruption of the sleep–wake rhythm may result in changes in appetite and food intake. Physicians should also be careful regarding this association.

It has been reported that neuropsychiatric symptoms are worse in dementia subjects when malnutrition is present (Kauzor *et al.*, 2023), and the emergence of eating problems, such as a decrease in appetite, will result in poor nutritional status. The vicious cycle of neuropsychiatric symptoms, decrease in appetite, and poor nutritional status may be stronger in people with DLB than in other dementias.

Constipation was the most distressing eating-related symptom for participants, and on this point both the participant–caregiver and the participant–physician concordance rates were also highest, although the latter was less than 30%. And participant–physician kappa coefficient for constipation was also significantly lower than participant–caregiver them. It has been reported that constipation is frequent and often precedes cognitive impairment in people with DLB (Chiba *et al.*, 2012), and mechanism such as delayed gastric emptying may be associated with constipation (Bove & Travagli, 2019). Physicians may have better awareness of this symptom compared with other eating-related problems. On the other hand, physicians' understandings of (concordance rates for) other symptoms including weight loss, dysphagia, weight gain, and increase in appetite were significantly lower than the corresponding participant–caregiver concordance rates. And the participant–physician kappa coefficient for four symptoms were also significantly lower than participant–caregiver them. Especially, physicians' understanding of weight loss and dysphagia was relatively low, despite their being the 2nd and 4th most distressing eating-related symptoms for participants; for these symptoms, the participant–caregiver concordance rates were greater than 50%. In any case, in this study, there was a discrepancy between patients and physicians in terms of constipation, weight loss, weight gain, and increase of appetite based on low kappa statistics and the McNemar's test results. These results suggest that physicians need to pay more attention to these symptoms from now.

A study based on a large dementia care health records database in Southeast London reported that weight loss was more common in people with DLB than in those with AD and vascular dementia (Soysal *et al.*, 2021). Dysphagia, which is commonly reported in people with DLB, can result in aspiration pneumonia and finally death (Easterling & Robbins, 2008). A study using videofluoroscopic swallowing examination (VFSE) reported that among 81 consecutive people with DLB, 32% reported symptoms of dysphagia such as swallowing difficulties or coughing (Londos *et al.*, 2013), 92% of these had a documented swallowing dysfunction on VFSE, and 88% suffered from pharyngeal dysfunction. Physicians should be more alert to these symptoms in the management of people with DLB.

There have been many reports on the use of NPI to cluster neuropsychiatric symptoms of AD subjects (Connors *et al.*, 2018; Hiu *et al.*, 2022; Kazui *et al.*, 2016; Nagata *et al.*, 2016; Poletti *et al.*, 2013). However, there have been no reports in subjects with DLB. In our sample, neuropsychiatric symptoms could be divided into three syndromes: psychosis syndrome, agitation syndrome, and depressive syndrome. Anxiety, disinhibition, and nighttime behavior were not included in any other cluster. It is well known that REM sleep behavior disorder appears as a prodromal symptom in DLB and can be independent symptom from other neuropsychiatric symptoms (Chan *et al.*, 2018). Among DLB subjects, disinhibition is not so common compared with other neuropsychiatric symptoms (Hashimoto *et al.*, 2015; Schwertner *et al.*, 2022). This low prevalence of disinhibition may have an effect on clustering. Anxiety, not depression, is reported to occur significantly more frequently in DLB than in AD, and anxiety also appears as a prodromal symptom (Segers *et al.*, 2020). Interestingly, anxiety was an independent symptom from depression in this study. Anxiety may thus be related to the pathological background of DLB. Future research is needed. This clustering of neuropsychiatric symptoms of DLB subjects is considered reasonable enough. From this point of view, this study is significant.

Limitation

The present study has some limitations, such as those inherent to questionnaire surveys. Despite efforts made to address this point (the movie provided and table with symptom definitions), there were particular issues with the reliability of the participant' answers. Most of the participants in this study were residing at home and their mean MMSE-J score was 20.9, suggesting that many of them had relatively mild DLB. The results of this study may

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not apply to all participant with DLB but rather to those with mild to moderate DLB. There are several potential symptoms of DLB that could contribute to eating problems those are not examined in detail in this study. Anosmia or olfactory dysfunction is reported to be associated with DLB rather than AD or other dementias. (McShane *et al.*, 2001) This may have contributed to eating problems in DLB. Also, gastrointestinal dysfunctions, including dysphagia, nausea and delayed gastric emptying, are reported to be significant comorbid features in PD or DLB, which occur commonly before the onset of motor symptoms(Bove & Travagli, 2019). Mechanisms such as delayed gastric emptying may have influenced eating problems in DLB. Visuoperceptual impairment, which is characteristic of DLB, may also have influenced on eating problems. (Mori *et al.*, 2000).

Finally, because this is an exploratory study, no correction for test multiplicity in the regression analysis was conducted.

Conclusions

In conclusion, this study investigated the relationship between eating problems and each of multiple symptoms including neuropsychiatric problems in DLB subjects and found that the presence of eating behaviors was largely related to depression and apathy, while the worsening of eating behavior was related to apathy and nighttime behavior. Importantly, physicians had relatively little understanding of eating problems. Physicians need to pay more attention to eating problems and their neuropsychiatric background in the long-term support and management of DLB subjects and their caregivers. We believe this study will lead to further improve the QOL of DLB subjects and their caregivers.

Conflicts of interest

SS has received funding form Eisai Co., Ltd and lecture fees from Sumitomo Pharma Co., Ltd., and Eisai Co., Ltd. MH has received fees for travel expenses from Sumitomo Pharma Co., Ltd. and lecture fees from Sumitomo Pharma Co., Ltd. and Eisai Co., Ltd. ST is an employee of Sumitomo Pharma Co., Ltd. HY is an employee of 3HMedi Solution Inc. MI has received research funding from Sumitomo Pharma Co., Ltd. and lecture fees from Sumitomo Pharma Co., Ltd. and Eisai Co., Ltd.

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Description of author(s)' roles

SS, MH, ST and MI contributed to study design, study conduct, or data collection. HY contributed to the data analysis, and all authors contributed to the interpretation of the results, writing or reviewing the manuscript, and provided their final approval of the manuscript for submission.

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