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Article

Association between the Intake/Type of Cheese and Cognitive Function in Community-Dwelling Older Women in Japan: A Cross-Sectional Study

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Abstract: While many studies have described the association between cognitive decline and eating habits, little attention has been paid to its association with cheese intake. In this cross-sectional study of 1,035 community-dwelling women aged ≥ 65, we investigated the association between intake/type of cheese and cognitive function. The anthropometry, functional ability, and the frequency of food intake, including cheese, were assessed. Cognitive function was assessed using the Mini-Mental State Examination (MMSE), and a score of 20–26 was defined as mild cognitive decline (MCD). We found that MMSE score was significantly different between the presence of cheese intake (cheese intake: 28.3±1.9; non-cheese intake: 27.8±2.2) and between the type of cheese consumed (Camembert cheese: 28.7±1.3; others: 28.3±1.9). After adjusting for confounders, multiple logistic regression revealed four significant independent variables for MCD: Camembert cheese intake (odds ratio [OR] = 0.448, 95% confidence interval [CI] = 0.214–0.936), age (OR = 1.114, 95% CI = 1.059–1.171), usual walking speed (OR = 0.2620, 95% CI = 0.109–0.621), and repetitive saliva swallowing test scores (OR = 0.865, 95% CI = 0.750–0.995). Our results, while based on cross-sectional data from Japanese community-dwelling older women, demonstrated that Camembert cheese intake is significantly associated with MCD.

Keywords: cheese intake; camembert cheese; MMSE score; mild cognitive decline; community-dwelling older women

1. Introduction

As the global population ages, it is crucial to extend a healthy longevity and support older adults in leading independent lives. Maintaining both physical and cognitive functions at high levels is essential to achieve this goal. To sustain cognitive function in older age, staying socially active, continuing to learn, exercising regularly, and eating a healthy diet are key strategies of lifestyle choices and practices [1–3]. High-quality cross-sectional, longitudinal, and interventional studies have investigated the impact of diet and nutrition on cognitive function. For instance, many studies have suggested that a dietary pattern rich in milk and dairy products can help prevent dementia and cognitive decline [4–7]. However, some studies have found no association, resulting in a lack of

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consensus. The recent systematic reviews on the effect of milk and other dairy products on the risk of cognitive performance decline in older individuals reported that such associations cannot be firmly established owing to remarkable heterogeneity in the methodology used among the observational studies [8,9].

Some studies have also focused on the type of cheese consumed. For example, intake of Camembert cheese extract has been reported to reduce β-amyloid and increase brain-derived neurotrophic factor (BDNF) levels in mice models of Alzheimer's disease [10]. A randomized controlled trial (RCT) on community-dwelling older adults with mild cognitive impairment (MCI) also reported that Camembert cheese intake increases BDNF levels [11]. An association between serum BDNF levels and cognitive function has been suggested in a previous report [12]. These results suggest that the effect on cognitive function may vary based on the type of cheese consumed. Notably, we previously found an inverse association between daily cheese intake and lower cognitive function [13].

Based on these findings, this study aimed to explore the association between cheese intake/type and cognitive function, assessed using the Mini-Mental State Examination (MMSE) in a randomly selected group of community-dwelling older women.

2. Materials and Methods

2.1 Study Participants

The participants in this study were 1,035 community-dwelling women aged ≥ 65 years who participated in Otasha-Kenshin, a comprehensive health examination conducted by the Tokyo Metropolitan Institute for Geriatrics and Gerontology in 2017. The participant selection process has been described in detail in our previous study [14] and is briefly described here. To ensure community representativeness, 6,788 older women aged ≥ 65 years (approximately 10% of the total female population of Itabashi) were randomly selected using the Basic Resident Register in 2017. After excluding 422 women who participated in another cohort study, invitation letters were sent to 6366 women. A total of 1035 women participated in the health examination in 2017.

The study protocol was approved by the Clinical Research Ethics Committee of the Tokyo Metropolitan Institute of Gerontology (TMIG) (ID R2-25). All the procedures were fully explained to the participants, and written informed consent was obtained.

2.2 Outcome Measures

2.2.1 Measurement of Anthropometric and Physical Function

Height and body weight were measured and used to derive the body mass index (BMI). The calf circumference of the non-dominant leg was measured with the participant seated with the knee and ankle at right angles and the feet resting on the floor. Measurements were made at the level of the widest circumference and subcutaneous tissue was not compressed. The grip strength of the dominant hand was measured using a hand-held Smedley-type dynamometer (Takei Scientific Instruments CO. Ltd. Japan), with the greater strength of two trials recorded. Usual walking speed was measured on a flat walking path of 11 m with indicators placed at the 3-m and 8-m mark. A stopwatch was used to measure the time taken to walk the 5-m distance between the indicators, and the faster time of two trials was recorded. Assistive walking devices were allowed when the participant expressed concerns about walking without a device or when the investigators suspected a risk of falling. Swallowing function was assessed using the Repetitive Saliva Swallowing Test (RSST) by placing the fingers at the Adam's apple to calculate the number of times saliva has been swallowed within 30 s.

2.2.2 Interview Survey

Face-to-face interviews were conducted to assess history of falls, urinary incontinence, Geriatric Depression Scale (GDS) scores, frequencies of food intake (cheese, milk, fish, meat, egg, soy products,

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potatoes, fruit, seaweed, green and yellow vegetables, fats, and oils), and chronic medical conditions, such as heart disease, hyperlipidemia, dyslipidemia, diabetes, osteoporosis, osteoarthritis (OA), and anemia.

The dietary variety scores (DVS) was calculated using the intake frequencies of 9 food categories (fish, meat, eggs, soy products, potatoes, fruit, seaweed, green and yellow vegetables, and fats and oils; in the original questionnaire, 10 items were calculated, including milk, but milk was considered to be in the same family as cheese in the present study; hence, it was excluded). For each participant, a score of 1 was given for each food category if it was eaten every day, and a score of 0 was given if it was eaten once every 2 days, once or twice a week, or no intake; the total score (0 to 9) was then calculated [15]. Cheese intake frequency and type were also investigated. Participants consuming cheese at least once or twice a week were classified into the "Cheese intake" group, whereas others were classified into the “Non-cheese intake” group. Considering the type of cheese consumed, the participants were categorized into the "Camembert cheese" and "Other cheese" groups.

2.2.3 Blood Indicators

Non-fasting blood samples were collected at baseline. Analyses were carried out centrally in one laboratory (Special Reference Laboratories, Tokyo, Japan). Lipid levels (total cholesterol, high-density lipoprotein [HDL] cholesterol, and triglycerides) were determined. Serum albumin was measured by bromocresol green method, glycated hemoglobin (HbA1c) by latex agglutination assay, and serum creatinine by an enzymatic assay.

2.2.4 Cognitive Function

Global cognitive status was assessed using the MMSE. Mild cognitive decline was operationally defined as MMSE scores of 20–26 [16,17]. Meanwhile, participants with an MMSE score ≤19 were excluded from the analysis due to suspected middle-stage to moderate dementia.

2.3 Data Analysis

Descriptive statistics are expressed as mean and standard deviation or frequency (%). Participants were classified into two groups based on MMSE scores: ≥ 27 and 20–26. The students' *t*-test was used for continuous variables, and the chi-square test was used for categorical variables.

Multiple logistic regression analyses were used to analyze factors associated with mild cognitive decline. The dependent variable was an MMSE score 26 and under and 20 and above ($20 \leq$ MMSE score ≤ 26). Model I included only the cheese type and intake status. Model II was adjusted for age, physical function, and physique factors. Model III was further adjusted for medical history, blood variables, swallowing function, urinary incontinence, depressive symptoms, and milk intake. Significant and nonsignificant variables were entered into the multiple logistic regression models to obtain the odds ratio (OR) and 95% confidence interval (CI).

P values less than 0.05 were considered statistically significant. All analyses were performed using the Statistical Package for Social Sciences (SPSS) version 25.0 (SPSS Inc., Tokyo, Japan).

3. Results

Of the 1035 women, 836 (80.9%) and 197 (19.1%) were categorized in the "cheese intake" and "non-cheese intake" groups, respectively. Concerning the type of cheese consumed, the majority (78.5%) consumed processed cheese, whereas fresh cheese, blue mold cheese, and camembert cheese were consumed by 7.1%, 1.6%, and 12.2%, respectively (Table 1).

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Table 1. Cheese intake of study participants.

Domain	Category	n	%
Frequency	Daily	271	26.2
	Once every 2 days	242	23.4
	Once or twice a week	323	31.3
	No intake	197	19.1
	Total	1033	100.0
Type [1]	Processed cheese	767	78.5
	Fresh cheese	69	7.1
	Camembert cheese	119	12.2
	Blue mold cheese	16	1.6
	Other	6	0.6
	Total	977	100.0

[1] Multiple answers.

Compared to the cheese intake group, the non-cheese intake group had lower DVS, higher creatinine levels, lower total cholesterol levels, higher GDS scores, higher prevalence of chronic diseases, a lower percentage of milk consumers, and lower total MMSE scores, including the MMSE sub-scale scores for temporal orientation (Table 2).

Table 2. Comparison of selected variables between the cheese intake and non-cheese intake groups.

Variables	Cheese Intake	n	Mean ± SD	*t*-value	*p*-value
Age, years	No	197	71.4 ± 4.2	1.418	0.079
	Yes	836	71.9 ± 4.5		
Calf circumference, cm	No	197	34.2 ± 3.0	1.050	0.147
	Yes	836	34.5 ± 2.9		
Grip strength, kg	No	196	21.1 ± 3.9	1.502	0.067
	Yes	829	21.6 ± 3.9		
Usual walking speed, m/s	No	195	1.3 ± 0.3	0.094	0.462
	Yes	835	1.4 ± 0.3		
RSST, times/30 s	No	197	3.8 ± 1.8	0.092	0.463
	Yes	828	3.8 ± 1.7		
DVS, points	**No**	**196**	**4.0 ± 1.9**	**5.069**	**<0.001**
	Yes	**833**	**4.8 ± 2.0**		
Creatinine, mg/dL	**No**	**196**	**0.67 ± 0.13**	**2.670**	**0.004**
	Yes	**836**	**0.71 ± 0.30**		
Total cholesterol, mg/dL	**No**	**196**	**222.6 ± 36.4**	**1.777**	**0.038**
	Yes	**836**	**227.7 ± 35.2**		
HDL cholesterol, mg/dL	No	196	68.8 ± 18.1	1.073	0.142
	Yes	836	70.3 ± 18.4		
Triglycerides, mg/dL	No	196	148.7 ± 82.2	1.180	0.120
	Yes	836	156.6 ± 91.4		
Albumin, g/dL	No	196	4.4 ± 0.3	0.385	0.350
	Yes	836	4.4 ± 0.3		
HbA1c, %	No	196	5.5 ± 0.6	0.138	0.445
	Yes	836	5.6 ± 0.6		
GDS score, points	**No**	**197**	**2.8 ± 2.8**	**3.336**	**0.000**
	Yes	**835**	**2.2 ± 2.3**		
MMSE score, points	**No**	**194**	**27.8 ± 2.3**	**1.962**	**0.025**
	Yes	**827**	**28.3 ± 1.9**		

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Temporal orientation	**No**	**194**	**4.8 ± 0.5**	**2.516**	**0.006**
	Yes	**830**	**4.9 ± 0.4**		
Spatial orientation	No	195	4.9 ± 0.4	0.908	0.182
	Yes	830	4.9 ± 0.3		
Registration	No	195	3.0 ± 0.1	1.228	0.110
	Yes	830	3.0 ± 0.2		
Attention and calculation	No	195	4.0 ± 1.3	2.633	0.004
	Yes	829	4.3 ± 1.0		
Remote memory	No	195	2.4 ± 0.8	2.414	0.008
	Yes	830	2.6 ± 0.7		
Other functions	No	195	8.7 ± 0.5	0.361	0.359
	Yes	828	8.7 ± 0.6		
Number of chronic disease, n	**No**	**197**	2.6 ± 0.7	**1.661**	**0.049**
	Yes	**831**	**2.3 ± 1.7**		
Diabetes, yes (%)	No	15/197	7.6	0.649	0.42
	Yes	79/836	9.4		
Hyperlipidemia, yes (%)	No	66/197	33.5	0.004	0.947
	Yes	278/836	33.3		
Falls, yes (%)	No	29/197	14.7	0.237	0.626
	Yes	112/836	13.4		
Urinary incontinence, yes (%)	No	79/197	40.1	0.233	0.629
	Yes	351/836	42.0		
Milk intake, yes (%)	**No**	**86/197**	**56.3**	**26.792**	**<0.001**
	Yes	**210/836**	**74.9**		

* Data are presented as mean and standard deviation (SD) for continuous variables and percentage for categorical variables. RSST: repetitive saliva swallowing test; DVS: dietary variety scores; HDL: high-density lipoprotein; HbA1c: hemoglobin A1c; GDS: geriatric depression scale; MMSE: mini-mental state examination; N: number. † Student's *t*-test for continuous variables and chi-square for categorical variables.

Figure 1 shows distribution of the MMSE scores among the study participants. A total of 866 (84.8%) participants had an MMSE score ≥ 27, and 151 (14.8%) had an MMSE score of 20–26. Four (0.4%) women with an MMSE score ≤ 19 were excluded from the analysis.

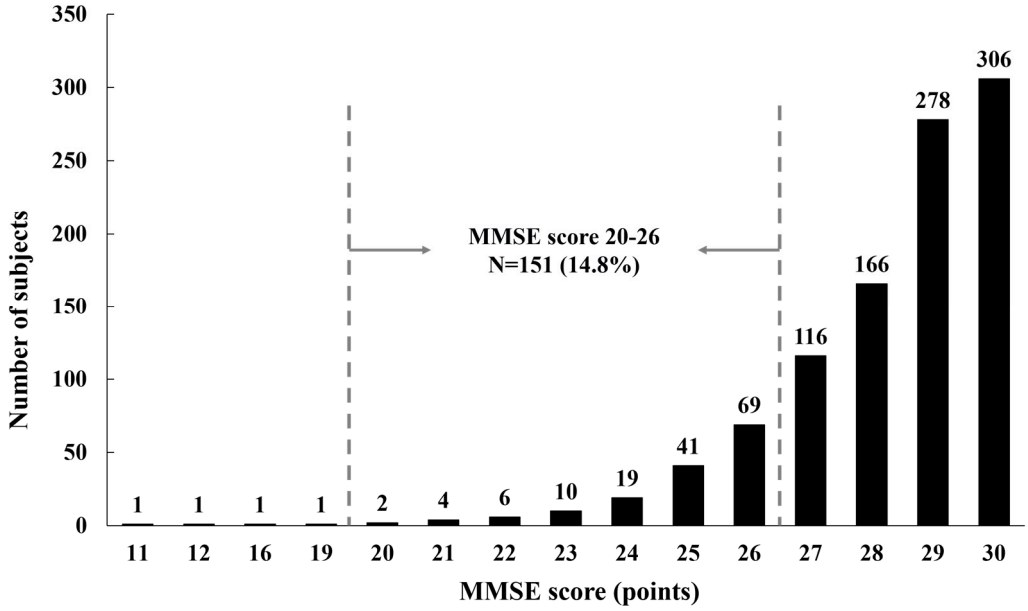

Figure 1. Distribution of the Mini-Mental State Examination scores. N = 1,021.

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Table 3 shows a comparison between the Camembert cheese intake and other cheese intake groups. The Camembert cheese intake group had smaller calf circumference, higher total MMSE score, and higher scores for the MMSE sub-scales of temporal orientation, attention and calculation, and other functions.

Table 3. Comparison of selected variables between the Camembert and other type cheese intake groups.

Variables	Category	n	Mean ± SD	*t*-value	*p*-value
Age, years	Other	759	71.8 ± 4.5	0.487	0.313
	Camembert	119	72.0 ± 4.8		
Calf circumference, cm	**Other**	**759**	**34.5 ± 2.8**	**1.680**	**0.047**
	Camembert	**119**	**34.1 ± 3.2**		
Grip strength, kg	Other	753	21.5 ± 3.8	1.131	0.129
	Camembert	118	22.0 ± 4.2		
Usual walking speed, m/s	Other	757	1.4 ± 0.3	0.892	0.186
	Camembert	119	1.4 ± 0.2		
RSST, times/30 s	Other	752	3.8 ± 1.7	0.770	0.221
	Camembert	118	3.9 ± 1.8		
DVS, points	Other	757	4.8 ± 1.9	0.148	0.441
	Camembert	118	4.8 ± 2.0		
Creatinine, mg/dL	Other	759	0.7 ± 0.3	0.645	0.260
	Camembert	119	0.7 ± 0.1		
Total cholesterol, mg/dL	Other	759	227.4 ± 35.4	0.150	0.440
	Camembert	119	227.9 ± 35.4		
HDL cholesterol, mg/dL	Other	759	70.0 ± 18.5	1.148	0.126
	Camembert	119	72.1 ± 18.1		
Triglycerides, mg/dL	Other	759	156.3 ± 91.8	0.556	0.289
	Camembert	119	151.3 ± 85.0		
Albumin, g/dL	Other	759	4.4 ± 0.3	1.312	0.095
	Camembert	119	4.4 ± 0.3		
HbA1c, %	Other	759	5.6 ± 0.6	0.507	0.306
	Camembert	119	5.5 ± 0.5		
GDS score, points	Other	758	2.2 ± 2.3	1.240	0.108
	Camembert	119	1.9 ± 2.2		
MMSE score, points	**Other**	**750**	**28.3 ± 2.0**	**2.527**	**0.006**
	Camembert	**119**	**28.7 ± 1.4**		
Temporal orientation	**Other**	**753**	**4.9 ± 0.4**	**2.430**	**0.008**
	Camembert	**119**	**4.9 ± 0.2**		
Spatial orientation	Other	753	4.9 ± 0.3	0.675	0.250
	Camembert	119	4.9 ± 0.2		
Registration	Other	753	3.0 ± 0.2	0.826	0.205
	Camembert	119	3.0 ± 0.2		
Attention and calculation	**Other**	**752**	**4.2 ± 1.1**	**1.827**	**0.035**
	Camembert	**119**	**4.4 ± 0.8**		
Remote memory	Other	753	2.5 ± 0.7	0.530	0.298
	Camembert	119	2.6 ± 0.6		
Other functions	**Other**	**751**	**8.7 ± 0.6**	**2.255**	**0.013**
	Camembert	**119**	**8.8 ± 0.4**		
Number of chronic disease, N	Other	755	2.3 ± 1.7	0.611	0.271
	Camembert	118	2.4 ± 1.9		
Diabetes, yes (%)	Other	69/759	9.1	0.059	0.807
	Camembert	10/119	8.4		

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Hyperlipidemia, yes (%)	Other	249/759	32.8	1.159	0.282
	Camembert	45/119	37.8		
Falls, yes (%)	Other	100/759	13.2	0.029	0.864
	Camembert	15/119	12.6		
Urinary incontinence, yes (%)	Other	311/759	41.0	0.538	0.463
	Camembert	53/119	44.5		
Milk intake, yes (%)	Other	558/759	73.5	0.237	0.626
	Camembert	90/119	75.6		

* Data are presented as mean and standard deviation (SD) for continuous variables and percentage for categorical variables. RSST: repetitive saliva swallowing test; DVS: dietary variety scores; HDL: high-density lipoprotein; HbA1c: hemoglobin A1c; GDS: geriatric depression scale; MMSE: mini-mental state examination; N: number. † Student's *t*-test for continuous variables and chi-square for categorical variables.

Table 4 shows a comparison of the measured variables between the group with MMSE scores ≥ 27 and those with MMSE scores of 20–26. Compared to the group with MMSE scores ≥ 27, the group with MMSE scores of 20–26 was older, with smaller calf circumference, weak grip strength, slower usual walking speed, lower RSST scores, lower albumin levels, and higher GDS scores.

Table 4. Comparison of selected variables between the MMSE score > 27 and MMSE scores of 20–26 groups.

Variables	Category	N	Mean ± SD	*t*-value	*p*-value
Age, years	**MMSE score ≥27**	**866**	**71.4 ± 4.4**	**6.403**	**<0.001**
	MMSE score 20–26	**151**	**73.9 ± 4.3**		
Calf circumference, cm	**MMSE score ≥ 27**	**866**	**34.5 ± 2.9**	**2.185**	**0.015**
	MMSE score 20–26	**151**	**33.9 ± 2.6**		
Grip strength, kg	**MMSE score ≥ 27**	**860**	**21.7 ± 3.9**	**3.800**	**<0.001**
	MMSE score 20–26	**150**	**20.4 ± 0.8**		
Usual walking speed, m/s	**MMSE score ≥ 27**	**863**	**1.4 ± 0.2**	**5.042**	**<0.001**
	MMSE score 20–26	**151**	**1.2 ± 0.3**		
RSST, times/30sec	**MMSE score ≥ 27**	**863**	**3.9 ± 1.8**	**2.941**	**0.002**
	MMSE score 20–26	**151**	**3.4 ± 1.4**		
DVS, points	MMSE score ≥ 27	864	4.6 ± 1.9	1.087	0.139
	MMSE score 20–26	149	4.8 ± 2.0		
Creatinine, mg/dL	MMSE score ≥ 27	866	0.7 ± 0.3	0.645	0.260
	MMSE score 20–26	151	0.7 ± 0.2		
Total cholesterol, mg/dL	MMSE score ≥ 27	866	227.0 ± 35.8	0.987	0.162
	MMSE score 20–26	151	223.9 ± 32.5		
HDL cholesterol, mg/dL	MMSE score ≥ 27	866	70.3 ± 18.6	1.116	0.132
	MMSE score 20–26	151	68.4 ± 17.2		
Triglycerides, mg/dL	MMSE score ≥ 27	866	155.4 ± 91.0	0.095	0.462
	MMSE score 20–26	151	154.6 ± 83.9		
Albumin, g/dL	**MMSE score ≥ 27**	**866**	**4.4 ± 0.3**	**2.304**	**0.011**
	MMSE score 20–26	**151**	**4.3 ± 0.3**		
HbA1c, %	MMSE score ≥ 27	866	5.5 ± 0.6	1.152	0.125
	MMSE score 20–26	151	5.6 ± 0.8		
GDS score, points	**MMSE score ≥ 27**	**865**	**2.2 ± 2.3**	**1.890**	**0.030**
	MMSE score 20–26	**151**	**2.6 ± 2.7**		
Number of chronic diseases, N	MMSE score ≥ 27	861	2.3 ± 1.7	0.080	0.468
	MMSE score 20–26	151	2.3 ± 1.8		
Diabetes, yes (%)	MMSE score ≥ 27	75/866	8.7	1.645	0.200
	MMSE score 20–26	18/151	11.9		
	MMSE score ≥ 27	299/866	34.5	2.599	0.107

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Hyperlipidemia, yes (%)	MMSE score 20–26	42/151	27.8		
	MMSE score ≥ 27	113/866	13.0	0.529	0.467
Falls, yes (%)	MMSE score 20–26	23/151	15.2		
	MMSE score ≥ 27	363/866	41.9	0.039	0.844
Urinary incontinence, yes (%)	MMSE score 20–26	62/151	41.1		
	MMSE score ≥ 27	624/866	72.1	0.64	0.424
Milk intake, yes (%)	MMSE score 20–26	104/151	68.9		

* Data are presented as mean and standard deviation (SD) for continuous variables and percentage for categorical variables. RSST: repetitive saliva swallowing test; DVS: dietary variety scores; HDL: high-density lipoprotein; HbA1c: hemoglobin A1c; GDS: geriatric depression scale; MMSE: mini-mental state examination; N: number. † Student's *t*-test for continuous categorical variables and chi-square for categorical variables.

As shown in Table 5, multiple logistic regression (Model III) identified four significant independent variables for mild cognitive decline: Camembert cheese intake (OR = 0.448, 95% CI = 0.214–0.936), age (OR = 1.114, 95% CI = 1.059–1.171), usual walking speed (OR = 0.2620, 95% CI = 0.109–0.621) and RSST scores (OR = 0.865, 95% CI = 0.750–0.995). In all three models, Camembert cheese intake was significantly associated with mild cognitive decline.

Table 5. Odds ratio (OR) and 95% confidence intervals (CI) for variables associated with MMSE scores of 20–26.

Independent Variable	Model I			Model II			Model III		
	OR	95% CI	p-value	OR	95% CI	p-value	OR	95% CI	p-value
Type of cheese, camembert cheese	**0.484**	**0.238–0.984**	**0.045**	**0.465**	**0.224–0.966**	**0.040**	**0.448**	**0.214–0.936**	**0.033**
Cheese intake, yes	0.816	0.354–1.881	0.634	0.640	0.269–1.521	0.312	0.605	0.252–1.455	0.262
Age, 1 year				**1.114**	**1.061–1.170**	**<0.001**	**1.114**	**1.059–1.171**	**<0.001**
Calf circumference, 1 unit				0.972	0.899–1.051	0.476	0.963	0.890–1.042	0.353
Grip strength, 1 unit				0.981	0.923–1.043	0.540	0.989	0.929–1.052	0.722
Usual walking speed, 1 unit				**0.259**	**0.113–0.591**	**0.001**	**0.260**	**0.109–0.621**	**0.002**
Diabetes, yes							1.724	0.899–3.304	0.101
Creatinine, 1 unit							0.964	0.548–1.695	0.898
Total cholesterol, 1 unit							1.001	0.995–1.007	0.738
Albumin, 1 unit							1.105	0.488–2.500	0.811
RSST, 1 unit							**0.865**	**0.750–0.995**	**0.046**
Urinary incontinence, yes							1.093	0.644–1.854	0.742
GDS score, 1 unit							0.964	0.879–1.057	0.436
Milk intake, yes							0.954	0.601–1.513	0.841

* RSST: repetitive saliva swallowing test; GDS: geriatric depression scale.

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4. Discussion

In this study, we analyzed the association between the type and frequency of cheese consumption and cognitive function using cross-sectional data from randomly selected community-dwelling older women. Our results suggest that Camembert cheese intake may prevent mild cognitive decline (MMSE scores of 20–26) (OR = 0.448). Although many measurements are employed for cognitive function, MMSE is the most widely used cognitive measurement tool. The significance of the results of this research will be discussed from various perspectives.

Many previous studies have highlighted the effect of consuming dairy products on suppressing cognitive decline and dementia onset [7,13]. However, many types of dairy products are available (such as those with high or low fat, fermented or not). Thus, describing the association between the cognitive function of older individuals and dairy as a whole is challenging. For example, some studies have reported that a high intake of full-fat dairy or saturated-fat dairy increases the risk of MCI, Alzheimer's disease, dementia, psychomotor retardation, and global cognitive dysfunction, whereas low fat dairy consumption showed to have beneficial effects [18].

Of the numerous existing studies on different dairy products, many have explored the association between cheese intake and cognitive function. Rahman et al. found that cheese intake was inversely associated with cognitive impairment in a simple logistic regression analysis (OR=0.59, 95% CI=0.42–0.84, P=0.003) [19]. Findings from a UK Biobank study conducted by Klinedinst et al. in 2020 demonstrated that daily cheese intake strongly predicted better fluid intelligence test scores over time (FH-: β=0.207, $p<0.001$) [20]. A Canadian longitudinal study performed by Tessier et al. revealed that cheese intake was positively associated with the executive function domain and verbal fluency [21]. Zhang et al. showed in a meta-analysis that dementia was one of the several health outcomes related to cheese consumption [22]. In an Italian case-control study by Filippini et al., fresh cheese intake was found to be positively associated with early-onset frontotemporal dementia (EO-FTD) but not with early-onset Alzheimer's dementia (EO-AD) [23]. Conversely, in the same study, aged cheese intake did not show any association with EO-FTD but had a slight positive association with EO-AD. Other studies have also questioned the association between cheese and cognition. de Goeij et al. [24] reported that cheese intake was associated with information processing speed but not with memory, suggesting that the influence may vary based on the cognitive function subscale. Ni et al. suggested that the consumption of dairy products and cognition showed no clear associations[25]. Dobreva focused on the relationship between Mediterranean diet and cognitive function and found positive relationships; however, cheese was not found to be related [26]. Thus, whether cheese affects human cognitive ability positively or not, is still controversial.

Existing evidence suggests the possibility that the area where each research is performed may be an important aspect in the debate on the association between cheese and cognition. Recently, a meta-analysis on the association between the amount of cheese intake and cognitive decline/dementia found that studies conducted in Asian countries showed an association between a high intake of dairy products and the prevention of dementia and cognitive decline. In contrast, studies conducted in Europe showed no such association [27]. The discrepancy may be related to the daily intake of dairy products, which ranges 29–165 g/day in Asian regions and 170–711 g/day in Europe [28]. In studies conducted in Asian regions, a high intake of dairy products led to a 43% lower risk of cognitive decline [29], whereas in regions with already high intake, no further health benefit was noted [9]. According to a study by Ozawa et al. on the Japanese diet, their mean daily intake of dairy products was 84.6 g, as assessed using a semi-quantitative food frequency questionnaire [7], which is lower than that observed in European regions. Notably, it is undeniable that the results of our study may be influenced by the underlying factor that the Japanese diet consists of a reduced daily intake of dairy products, although it cannot be clarified from the data of this study. Thus, this fact should be taken into consideration when interpreting the results of this study.

Dairy products are a heterogeneous food group, including fermented and nonfermented foods, and the percentage composition of their nutrients, such as fats and sodium, also varies. Dairy products rich in proteins, minerals, vitamins, and essential amino acids are directly or indirectly associated with cognitive function [30]. Among dairy products, fermented products, in particular, are

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effective in preventing cardiovascular diseases or diabetes [31,32]; moreover, these act as mediators of the association between the use of dairy products and cognitive decline [33]. In 2021, Tessier et al. analyzed data from 7,945 men and women aged ≥ 65 years who participated in the Canadian Longitudinal Study on Aging and observed a positive and independent association between total fermented dairy intake and executive function domains emphasizing the usefulness of fermented dairy intake [21].

Cheese is also a fermented dairy and expected to have health benefits through numerous bioactive compounds generated during ripening [34]. In fact, we previously reported the effect of white mold cheese (MFC; camembert cheese) on BDNF in community-dwelling older Japanese women MCI in an RCT. A significant interaction was observed in BDNF after a three-month intervention of MFC intake [11].

Upon fermentation of the white mold *Penicillium camemberti*, functional lipids such as oleamide and dehydroergosterol are produced. Ano et al. pointed out that these components help suppress brain inflammation [10,35]. Furthermore, a recent study has shown that oleamide contributes to maintaining cognitive function and improving sleep in humans [36]. Through these actions, it can be speculated that the intake of white mold cheese, including camembert cheese, may help suppress mild cognitive decline. However, this mechanism cannot be elucidated from the data of this study.

This study has some limitations. First, our finding of a relationship between Camembert cheese intake and mild cognitive decline was obtained from an analysis of cross-sectional data. Whether Camembert cheese intake contributes to reducing the risk of mild cognitive decline cannot be elucidated from the present result and must be further investigated by conducting a longitudinal study. Second, information on the status of Camembert cheese intake was based on self-reporting during the interview and was not objectively quantified. Third, although many cut-off values have been proposed for defining mild cognitive decline, the cut-off value used in the present study was determined operationally as an MMSE score of 20–26, according to that proposed by Jan Versijpt et al. and Arevalo-Rodriguez et al. [16,17]. Finally, this study was limited to female participants. The percentage of individuals requiring long-term care due to dementia is reportedly higher among women (19.9%) than in men (14.4%) [28], suggesting that women may be more severely affected by cognitive decline. Thus, we performed the analysis by limiting the participants to women. The influence of sex differences on the association between cheese intake and cognitive function should be examined in the future.

5. Conclusions

In this cross-sectional study of Japanese community-dwelling older women, our results suggest that Camembert cheese intake is associated with mild cognitive decline even after adjusting for multiple confounding factors. A large-scale longitudinal analysis should be conducted in the future to elucidate the causal relationship.

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Institutional Review Board Statement: This study was conducted according to the guidelines of the Declaration of Helsinki and was approved by the Ethics Committee of the Tokyo Metropolitan Institute of Gerontology (approval R2-25).

Informed Consent Statement: Written informed consent was obtained from all subjects involved in this study.

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Data Availability Statement: The data presented in this study are not publicly available due to ethical and legal restrictions imposed by the Ethics Committee at the Tokyo Metropolitan Institute of Gerontology but are available from the corresponding author upon reasonable request.

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Conflicts of Interest: This study was conducted as a part of the "Epidemiology study of the relationship between dairy product intake and cognitive function" commissioned by Meiji Co., Ltd., under a contract with Oberlin University. T.S. holds the position of Commissioned Research Chair, and H.K. is a member of the Commissioned Research Group. K.N., C.O., and M.S. are employees of Meiji Co., Ltd. The other authors declare no conflict of interest. The funders had no role in the study design, collection, analysis, or interpretation of the data, or the writing of the manuscript, or decision to publish the results.

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