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Original article

Adequacy of nutrition and body weight in patients with early stage dementia: The cognition and aging study

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SUMMARY

Background & aims: Recent evidence highlights the effects of obesity, diabetes and hypertension in the development of Alzheimer's disease. Involuntary body weight changes in patients with different stages of dementia can be related to clinical factors of the patient per se or support from their caregivers. Understanding the interactions among factors is important to establish a monitoring paradigm to guide treatment strategies.

Methods: A total of 345 patients with very mild (n = 224) and mild stage (n = 121) dementia were enrolled from a multi-disciplinary dementia clinic. Clinical data (comorbidities, Mini-Mental State Examination [MMSE] scores, neuropsychiatric inventory [NPI] scores, eating behavior questionnaire), nutritional state (Mini-Nutritional Assessment [MNA] or MNA short form [MNA-SF]) and body mass index (BMI) were recorded. Nutritional state and BMI served as the two major outcome measures, and factors for analysis included diagnosis, dementia severity and clinical data.

Results: There was a significant correlation between MNA-SF and MNA ($r = .898$, $p < 0.01$), but a 24% mismatch in case dislocation was found using the at-risk or malnutrition criteria. Factors related to obesity included male sex, higher MNA-SF and MNA scores, diabetes mellitus and hypertension, while acceptable discrimination for obesity (BMI≧23 kg/m^2) was obtained with a MNA-SF score of 12/13 or MNA score of 21/22. NPI was the only independent factor related to both MNA-SF ($\beta = -.06$, $P < 0.001$) and MNA ($\beta = -.1$, $P < 0.001$). A BMI of 22–23 kg/m^2 was adequate in this group of patients with early stage dementia from nutritional and comorbidity perspectives. After controlling for BMI, the patients with advanced dementia had higher swallowing problem and appetite change scores.

Conclusions: In these patients with early stage dementia, a higher BMI indicated adequate nutritional status and higher MMSE, but also higher rates of comorbidities, diabetes mellitus and hypertension.

1. Introduction

1.1. Dementia related to global aging and comorbidities

In Taiwan, the percentage of people aged ≥65 years has increased from 4.1% in 1980 to 14% in 2018, and this increase in the elderly population has been associated with an increase in the prevalence of dementia [1]. The most common clinical diagnosis of dementia is Alzheimer's disease (AD) [2]. Recent

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estimates suggest that over half of all cases of AD worldwide may be attributed to potentially modifiable risk factors including diabetes mellitus (DM), midlife hypertension, midlife obesity, physical inactivity, smoking, depression, and low educational attainment [3].

1.2. Clinically feasible tools for nutritional status measures in patients with dementia

In the dementia care paradigm, adequate education regarding nutrition and interventions require tools that can be used clinically. The Mini-Nutritional Assessment (MNA) [4,5] is a commonly used screening tool to assess nutritional state, and it has been shown to have high sensitivity and specificity for malnutrition in the elderly [6,7]. The European Society for Clinical Nutrition and Metabolism (ESPEN) defines malnutrition as "a state resulting from the lack of intake or uptake of nutrition that leads to altered body composition (decreased fat free mass) and body cell mass leading to diminished physical and mental function and impaired clinical outcome from disease" [8]. The short form of the MNA shortens the assessment time. In a dementia cohort with 6 years of longitudinal follow-up [9], the modified version of the MNA (mMNA) showed good ability to predict a decline in Mini-Mental State Examination (MMSE) score. The nutritional status in patients with dementia can be affected by the stage of dementia. The MNA and MNA-SF are commonly used screening tools to detect elderly persons [5] and patients with dementia [9–11] who are at risk of malnutrition. The diagnostic criteria for malnutrition according to the ESPEN Consensus Statement [12] require a validated risk screening tool followed by a body mass index (BMI) of <18.5 kg/m^2. Another method to diagnose malnutrition includes unplanned weight loss more than 10% of usual weight regardless of the length of time it take to lose this weight, or more than 5% over 3 months, combined with either a reduced BMI (<20 kg/m^2 if $<$ 70 years old, or <22 kg/m^2 if $\geq$ 70 years old) or a low fat-free mass index (<15 kg/m^2 in females, <17 kg/m^2 in males). However, as the disease progresses, changes in eating behavior may cause unbalanced nutrient intake. Further studies are needed to elucidate whether MNA scores have different clinical implications in patients with different stages of dementia.

1.3. Confounders of involuntary body weight change

Nutritional status in patients with dementia has been reported to be closely related to cognitive performance and neuropsychiatric symptoms [9,10,13]. Involuntary body weight changes in patients with dementia can be related to clinical factors of the patient or support from their caregivers. Weight changes or abnormalities in nutritional status in patients with dementia have been attributed to eating behavior [11], impaired care support, or the effect of comorbidities. For example, patients may have the ability to regulate dietary intake but not the type or quantity of food in the early stage of dementia. As the disease progresses, their self-care may worsen, and their nutritional status may depend on help from caregivers. Patients with dementia are often elderly and have coexisting metabolic diseases. Two meta-analyses found that elderly subjects had small intra or intermediate variations in BMI, and that this could be used as a good nutritional indicator [14,15]. In patients with dementia, the presence of DM, hyperlipidemia or other systemic comorbidities can interact with cognitive status and lead to changes in BMI status. It is important, therefore, to understand which comorbidities may interfere with BMI values.

1.4. Purpose of this study

The aim of this study was to evaluate associations among nutritional state, BMI, eating behavior, dementia stage and recently established risk factors of obesity, DM, and hypertension in a group of patients with mild stage dementia in a dementia-specific multidisciplinary clinic.

2. Material and methods

This study was conducted in accordance with the Declaration of Helsinki and was approved by the Institutional Review Board of Chang Gung Memorial Hospital. The study participants were treated at the multi-disciplinary dementia outpatient clinic at Kaohsiung Chang Gung Memorial Hospital. The clinical diagnosis of each patient was reached by the consensus of a panel composed of neurologists, psychiatrists, neuropsychologists, neuroradiologists and experts in nuclear medicine [16,17]. The clinic allows for integrated measurements and interventions in patients diagnosed with dementia. The team members included a neurologist, dietitian, nurse, physical activity trainer, case manager and social worker. A total of 345 subjects (144 males, 201 females) were included in this study. At the integrated clinic, each patient was accompanied by at least one family member (or caregiver) who stayed with the patient for more than 10 h per week.

2.1. Demographic and neurobehavioral assessments

Demographic data of the patients including age, educational level, comorbidities, medications and whether they were vegetarians were recorded after enrollment. The demographic factors represented independent variables in statistical analysis. For disease comorbidities, we recorded the presence of DM, hypertension, hyperlipidemia, hepatic disease defined as the result of a liver function test being >2-fold higher than the upper threshold, and renal dysfunction defined as an estimated glomerular filtration rate <60 ml/min/1.73 m^2.

A trained neuropsychologist administered the neurobehavioral tests. Total MMSE (range: 0–30) [18] and clinical dementia rating (CDR) (i.e. 0 = normal; .5 = questionable dementia; 1 = mild dementia; 2 = moderate dementia; 3 = severe dementia) [19] scores were used as a global assessment of cognitive and functional status. The MMSE is a general measurement of the cognitive ability of a patient, while the CDR score represents the daily functional capacity of daily living independent of physical activities. For the behavioral observations, we used the 12-item version of the neuropsychiatric inventory (NPI) [20], with scores ranging from 0 to 144.

2.2. Nutritional status and criteria

The MNA consists of the short form (MNA-SF: 6 items with a maximum score of 14) and assessment (12 additional items with a maximum score of 16) parts. The MNA-SF and assessment parts were evaluated in all of the participants. According to the MNA-SF criteria [7,21], a score of 0–7 was defined as malnutrition, 8–11 as being at risk, and 12–14 as normal nutritional status. For the MNA (maximum score of 30) [22], a score below 17 was defined as malnutrition, 17–23.5 as being at risk, and 24–30 as normal nutritional status.

2.3. Eating behavior questionnaire

We recorded eating behavior using a questionnaire [23–26] consisting of 41 questions and five major domains: swallowing

problems (6 items), changes in appetite (9 items), food preference (6 items), eating habits (8 items) and other oral behavior (12 items). All information was gathered from the caregiver. We emphasized that a "symptom" should reflect a substantial change from the patient's premorbid state and not a longstanding character trait. We scored the presence of each item in each patient.

2.4. BMI stratified into three groups

The height and weight of each patient were recorded to calculate the BMI. According to the World Health Organization criteria [27] for Asians, we stratified the study population into three BMI groups: under-weight group, BMI <18.5 kg/m^2; normal weight group, BMI 18.5–22.9 kg/m^2; and over-weight group, BMI ≧23 kg/m^2.

2.5. Statistical analysis

Clinical data were expressed as mean ± standard deviation. The Student's t test or one-way analysis of variance followed by post-hoc Scheffé's test was used for multiple comparisons of continuous variables as appropriate, and the chi-square test was used for categorical variables. Pearson correlation analysis was used to analyze the relationships between two continuous variables, and multiple regression models were used to assess associations among demographic and other factors and nutritional status. Receiver operating characteristic (ROC) curves were used to assess the cutoff values of MNA-SF and MNA scores for abnormal values of BMI, and the percentages of cases using the MNA-SF and MNA and the at-risk or malnutrition criteria were analyzed to explore possible inconsistencies. Youden's index was used to define the best cutoff values of MNA-SF and MNA, with acceptable discrimination being defined as an area under the ROC curve (AUC) of .7–.8 [28]. All statistical analyses were conducted using SPSS software (IBM SPSS Statistics Version 22.0). Statistical significance was set at $p < 0.05$.

3. Results

3.1. Demographic data

The demographic data of the 345 patients are presented in Table 1. The majority of the patients had AD (n = 267, 77.4%). Two patients had behavioral variants of frontotemporal dementia, and three had semantic dementia. The remaining patients had diagnoses including vascular dementia (4.4%), mixed type dementia (2.6%), dementia with Lewy bodies (.6%), and Parkinson's disease dementia (4.7%). The prevalence of eating behavioral changes in falling order of frequency were changes in appetite, eating habits, swallowing problems and food preferences (Table 1).

There was a high correlation between MNA-SF and MNA scores ($r = .898$, $p < 0.01$). Using the MNA-SF and MNA pre-defined cutoff criteria, we found that there was a 24% mismatch in case dislocation in the three nutritional state groups (normal, at-risk, malnutrition). Twenty-nine percent of the patients who were assessed as having normal nutritional status according to the MNA-SF were categorized as being at risk of malnutrition according to the MNA criteria. In addition, 35% of the patients who were assessed as being at risk of malnutrition according to the MNA-SF were categorized as having a normal nutritional status according to the MNA criteria. Moreover, 22% of the patients who were assessed as having malnutrition according to the MNA-SF were assessed as being at risk of malnutrition according to the MNA criteria, and 14% of the patients who were assessed as being at risk of malnutrition according to the MNA-SF were assessed as having malnutrition according to the MNA criteria. Factor analysis suggested that the discrepancies were not driven by any particular item within the MNA-SF (Fig. 1). As shown in Fig. 1, we compared differences in items A-F of the MNA with the results of the nutritional outcome criteria (normal/at risk/malnutrition state) in the two phases (screening and assessment parts). Factors consistently associated with the at-risk and malnutrition groups in both the MNA and MNA-SF (Supplementary Table 1) included female sex, lower MMSE score, higher NPI score, lower BMI and a CDR ≥1. The results used to stratify the patients into four BMI groups using the Asian criteria are shown in supplementary Table 2. As the results for the over-weight and obesity groups were not significantly different with regards to the scores of MNA-SF and MNA or case percentages with regards to nutritional status, we stratified the patients into three BMI groups as per the major results of group classification.

Table 1
Demographic data of the participants (n = 345).

Variables	Mean ± SD/Median (Q1-Q3)/n (%)
Age (years)	75.48 ± 9.63
Mini-Mental State Examination	17.69 ± 6.99
Body mass index (kg/m^2)	23.61 ± 3.60
Mini Nutritional Assessment-screening	10.69 ± 2.52
Mini Nutritional Assessment	22.48 ± 4.27
Neuropsychiatric Inventory	2 (0–10)
Numbers of Comorbidity	1 (0–2)
Numbers of medication use	5 (3–7)
Eating behavior Questionnaire[a]	1 (0–3)
Swallowing problems[b]	88 (25.8%)
Appetite change[b]	144 (42.2%)
Food preference[b]	78 (22.9%)
Eating habits[b]	99 (29%)
Other oral behaviors[b]	21 (6.2%)
Gender	
Male sex	144 (41.7%)
Female sex	201 (58.3%)
Clinical Dementia Rating	
.5	224 (64.9%)
1	86 (24.9%)
2	32 (9.3%)
3	3 (.9%)
Marital status	
Unmarried	1 (.3%)
Married	343 (99.7%)
Education (years)	
0	79 (23%)
lower than 7 years	129 (37.6%)
> 7 years	135 (39.4%)
Major Caregiver	
Spouse	140 (40.6%)
Children	172 (49.8%)
Others	33 (9.6%)

Numbers indicate Mean ± standard deviation; Median (Q1–Q3 interquartile range) or case numbers (%) as appropriate.
[a] Ikeda et al., 2002 [23]; Aselage & Amella, 2010 [24]; Chang & Roberts, 2008 [25]; Hsiao et al., 2013 [26].
[b] n = 341 (4 missing data).

3.2. Demographic factors associated with BMI status

The factors that influenced BMI are listed in Table 2. Post-hoc Scheffé's test was used to analyze the differences between groups. The over-weight group was associated with male sex, higher MMSE score, number of comorbidities, higher MNA-SF and MNA scores, and the presence of DM and hypertension (Table 2). There were significantly more vegetarians in the under-weight group, and the over-weight group had more coexisting diseases including hypertension (55.2%), hyperlipidemia (31.3%) and DM (29.7%).

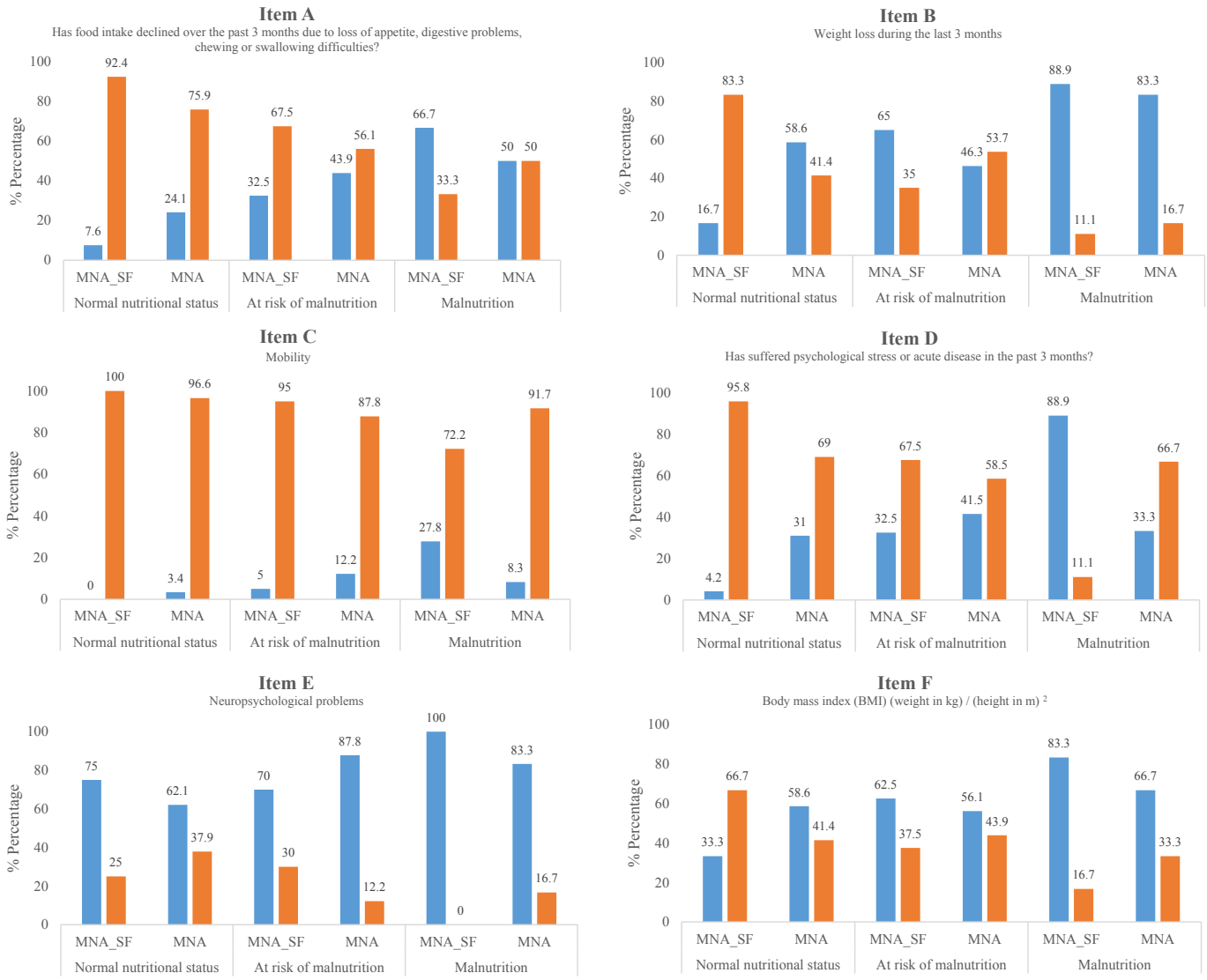

Fig. 1. Shows discrepancies in case dislocations (percentage) in items A-F in the three nutritional groups and nutritional indicator scores of Mini-Nutritional Assessment (MNA) or MNA short form (MNA-SF). The orange color represents the percentage of subjects obtaining a maximum score in each item, and the blue color shows those who did not obtain a maximum score. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

3.3. Regression model to predict MNA-SF or MNA scores

After accounting for the possible effects of the MMSE and BMI, the factor related to both the MNA-SF and MNA was NPI score (Table 3). The NPI significantly predicted MNA and MNA-SF scores among the patients who had hypertension (MNA $\beta = -.14$, MNA-SF $\beta = -.09$; all $p < 0.001$), DM (MNA $\beta = -.07$, $p = 0.032$; MNA-SF $\beta = -.05$, $p = 0.014$), and hyperlipidemia (MNA $\beta = -.11$, MNA-SF $\beta = -.07$; all $p < 0.001$). Considering comorbidities and nutritional status, a BMI of 22–23 kg/m^2 may be considered as adequate in patients with dementia.

3.4. Independent effects of nutritional state, BMI and dementia severity

Patients with a CDR of .5 had significantly higher MNA-SF and MNA scores ($p < 0.001$) and a lower total score of eating behavior ($p < 0.001$) than those with a CDR $\geq$1. Results of the eating behavior questionnaire suggested that the CDR $\geq$1 group had higher rates of choking, loss of appetite and taking a long time to swallow food or liquids.

After stratifying the patients into two CDR stages, we compared the MNA-SF, MNA and EBQ in three BMI ranges (Table 4). In those with a CDR of .5, the over-weight group had higher MNA-SF and MNA scores, and also significantly lower scores in swallowing problems (coughing or choking when swallowing; taking a long time to swallow food or liquids) and changes in appetite (loss of appetite). In those with a CDR $\geq$1, the MNA and MNA-SF scores were significantly different among the three BMI groups as over-weight > normal > under-weight. However, the differences were not related to any of the eating behavior problems.

3.5. ROC analysis of MNA-SF/MNA using BMI

Using BMI <18.5 kg/m^2 as the cutoff point, we assessed the AUC of MNA-SF and MNA to detect those who were under-weight. The AUCs of MNA-SF and MNA were .32 and .304, respectively, suggesting no discriminative value. The patients were further stratified into two CDR groups (CDR of .5 and $\geq$1), however the AUCs of MNA-

Table 2
Factors associated with the body weight index (BMI) status.

Variables	BMI for Asian criteria			*P value*	*Post Hoc*
	Underweight[a]	Normal[b]	Overweight[c]		
Case numbers (n = 345)	23	130	192		
Male/female[d]	4/19	51/79	89/103	< **.05**	
Age (years)	78.87 ± 8.06	75.12 ± 9.51	75.32 ± 9.84	.213	
Mini-Mental State Examination	14.83 ± 7.47	16.60 ± 7.25	18.77 ± 6.56	< **.01**	c> a, b
Neuropsychiatry Inventory Score	15.65 ± 19.78	6.92 ± 10.25	6.36 ± 11.08	.082	
Numbers of Comorbidity	.70 ± .82	1.09 ± 1.02	1.49 ± 1.21	< **.001**	c>a, b
Numbers of Medications use	4.41 ± 3.47	5.34 ± 3.19	5.62 ± 3.45	.259	
MNA-SF	7.91 ± 2.75	9.66 ± 2.39	11.72 ± 1.99	< **.001**	c>b>a
Mini Nutritional Assessment	17.65 ± 4.96	21.10 ± 4.17	24.00 ± 4.17	< **.001**	c>b>a
Normal/at risk/malnutrition state[e]	2/14/7	42/65/23	120/62/10	< **.001**	
DM (−)/DM(+)	21/2	103/27	135/57	< **.05**	c>a
Hypertension (−)/(+)	16/7	78/52	86/106	< **.01**	c>a, b
Hyperlipidemia (−)/(+)	20/3	97/33	132/60	.135	
CDR .5/CDR ≥1	12/11	77/53	135/57	.051	
Vegetarian (−)/(+)[f]	20/3	120/8	185/5	< **.05**	a>c

Data presented as mean ± standard deviation or case numbers.
MNA-SF = Mini Nutritional Assessment Screening Form; DM = Diabetes Mellitus; CDR=Clinical Dementia Rating.
[a] BMI <18.5 kg/m^2
[b] BMI 18.5~22.9 kg/m^2
[c] BMI ≧23 kg/m^2
[d] More female in the underweighted group compared with the other two BMI groups.
[e] Post-hoc scheffé's test analysis showed Normal nutritional group in the overweighted group compared with the normal or underweighted BMI groups in the at risk or malnutrition state.
[f] Vegetarian case number = 341 (4 missing data).

Table 3
Multiple regression analysis for Mini Nutritional Assessment scores.

Factors	B	S.E.	*t*	*p*	95% C.I.	
					Lower	Upper
Mini Nutritional Assessment Short form (N = 345)						
Intercept	11.02	.27	41.10	.000	10.49	11.54
Gender (male as reference)	-.42	.26	−1.60	.112	-.94	.10
Comorbidity						
Presence of Diabetes Mellitus (None of Diabetes Mellitus as reference)	.27	.38	.71	.482	-.48	1.01
Presence of Hypertension (None of Hypertension as reference)	-.19	.33	-.57	.572	-.85	.47
Numbers of comorbidity	.27	.18	1.56	.119	-.07	.62
Neuropsychiatric Inventories	-.06	.01	−5.11	**.000**	-.08	-.04
Mini Nutritional Assessment (N = 345)						
Intercept	23.72	.45	52.20	.000	22.83	24.61
Gender (male as reference)	−1.26	.45	−2.82	**.005**	−2.15	-.38
Comorbidity						
Presence of Diabetes Mellitus (None of Diabetes Mellitus as reference)	.23	.64	.35	.726	−1.04	1.49
Presence of Hypertension (None of Hypertension as reference)	-.29	.57	-.51	.609	−1.40	.82
Numbers of comorbidity	.22	.30	.73	.469	-.37	.80
Neuropsychiatric Inventories	-.10	.02	−5.14	**.000**	-.13	-.06

B = beta coefficient; S.E. = Standard Error; C.I. = Confidence Interval.

Table 4
Factors analysis according to the clinical dementia rating (CDR) scores.

	Mean ± SD	Underweight[a]	Normal[b]	Overweight[c]	*P value*	*Post Hoc*
CDR = .5 (n = 224)						
BMI	23.87 ± 3.55	17.14 ± 1.20	21.08 ± 1.21	26.05 ± 2.60	< **.001**	c>b>a
MNA-SF	11.28 ± 2.15*	9.17 ± 1.59*	10.06 ± 2.19*	12.16 ± 1.65*	< **.001**	c>a, b
MNA	23.67 ± 3.53*	20.17 ± 2.67*	22.16 ± 3.84*	24.85 ± 2.83*	< **.001**	c>a, b
EBQ	1.56 ± 2.13*	3.08 ± 2.75	1.39 ± 2.24*	1.51 ± 1.96*	< **.05**	a>b, c
CDR ≥ 1 (n = 121)						
BMI	23.15 ± 3.65	17.49 ± .75	20.90 ± 1.31	26.33 ± 2.32	< **.001**	c>b>a
MNA-SF	9.6 ± 2.78	6.55 ± 3.14	9.08 ± 2.56	10.68 ± 2.34	< **.001**	c>b>a
MNA	20.28 ± 4.64	14.91 ± 5.52	19.56 ± 4.17	21.99 ± 3.93	< **.001**	c>b>a
EBQ	3.09 ± 3.49	2.00 ± 1.95	3.36 ± 3.24	3.07 ± 3.90	.507	

SD=Standard Deviation; MNA-SF = Mini Nutritional Assessment short form; MNA = Mini Nutritional Assessment; BMI=Body Mass Index; *p < 0.05 between CDR = .5 and CDR ≥1; EBQ = Eating behavior questionnaire.
[a] BMI <18.5 kg/m^2.
[b] BMI 18.5~22.9 kg/m^2.
[c] BMI ≧23 kg/m^2.

SF and MNA still showed no discriminative ability (all four groups, AUC <.3).

In contrast, the AUC showed acceptable discrimination for MNA-SF (AUC = .756) and MNA (AUC = .705) using the over-weight criteria as the cutoff value (BMI ≧23 kg/m^2). A cutoff value of 12/13 in the MNA-SF showed a sensitivity of .458 and specificity of .908, and a cutoff value of 21/22 in the MNA showed a sensitivity of .833 and specificity of .485. Subgroup analysis showed that acceptable discrimination was driven by those with a CDR of .5 (MNA-SF AUC = .785; MNA AUC = .708) compared to those with a CDR ≥1 (MNA-SF AUC = .681, MNA AUC = .669).

4. Discussion

4.1. Major findings

This study explored the clinical factors related to obesity and poor nutritional status in patients with dementia, and there were three major findings. First, we determined acceptable cutoff values of the MNA-SF and MNA to detect the over-weight patients [27]. Second, although the MNA and MNA-SF were highly correlated with BMI values overall, the patients with a CDR of .5 and the same BMI range as those with a CDR ≥ 1 still showed differences in nutritional scores. This suggests that the severity of dementia may have interfered with the nutritional status after adjusting for the effect of BMI, and that the factors were driven by swallowing problems and appetite changes in the patients with an advanced stage of dementia. Finally, there was a 24% mismatch between the MNA-SF and MNA scores in differentiating between the patients at risk and those with malnutrition. This may be due to patient-specific factors related to dementia such as item E (neuropsychological problems), item N (mode of feeding), item O (self-view of nutritional status), and item P (compared with other people of the same age, how does the patient consider his/her health status). Therefore, the scoring factors in patients with an advanced stage of dementia should be modified or carefully assessed when dislocating cases based on the original cutoff values.

4.2. Factors associated with being over-weight in the patients with dementia

While most previous studies have focused on factors associated with being under-weight in patients with dementia, we specifically explored factors related to obesity in the current study. Previous studies have suggested that a diagnosis of frontotemporal dementia may be associated with more eating behavior problems [23] that cause weight gain. However, this diagnosis may not be the only factor, as only .6% of the patients in our study population had frontotemporal dementia. Most of our study population had AD, and more than half were classified as being over-weight based on the Asian BMI criteria.

4.3. Adequate BMI should balance nutrition, BMI and dementia stage in patients with dementia

In our study population the BMI was 23.61 ± 3.6 kg/m^2, similar to that reported in Japan (23.3 ± 4.0 kg/m^2) [29], but lower than that reported in Sweden (24.6 ± 4.3 kg/m^2) [30]. Our results stated that a BMI >23 kg/m^2 was associated with the presence of hypertension and DM, consistent with another study in the elderly [31]. A range of BMI to estimate the presence of hypertension, hyperlipidemia, DM or other cardiovascular risk factors has been reported in males (23.5–25.5 kg/m^2) and females (24.9–27.4 kg/m^2) [32]. One study conducted in Asia suggested best BMI values to estimate hypertension of 23.8 kg/m^2 in males and 24.1 kg/m^2 in females, and 24.3 kg/m^2 in males and 23.2 kg/m^2 in females to estimate DM [27,33].

Underweight in the elderly should be avoided, as it may represent protein-energy malnutrition [34] and an increased risk of mortality [29]. The debate as to what can be considered an ideal BMI range seems to depend on the outcome measure of interest. From the perspective of nutritional status, the ESPEN guidelines suggest that the elderly should maintain a BMI >22 kg/m^2 [30,35–37]. From nutritional status and comorbidity perspectives, our study suggests that considering comorbidities and nutritional status, a BMI of 22–23 kg/m^2 may be considered as adequate in patients with dementia.

4.4. Factors associated with malnutrition in the patients with dementia

Body weight loss and malnutrition [30,36,37] have been associated with a higher risk of mortality [38] in dementia patients. One longitudinal study [11] reported that 91.6% of dementia patients were at risk of malnutrition, while 52.5% of our patients were assessed as being at risk of malnutrition or were malnourished. Complex interactions exist between disease state and nutritional status [14]. Our regression model supported these findings, suggesting that NPI scores may be significantly associated with nutritional status. We also found that eating behavior problems may explain the relationship between cognitive ability and nutritional status. Several studies have suggested that the presence of hypertension, DM, and hyperlipidemia are associated with nutritional status [11,37], however, we found no such significance in our dementia patients.

The presence of eating behavior problems can cause malnutrition [11,39], and changes in eating behavior problems were most significant in our CDR ≥1 group. Of these eating behavior problems, swallowing problems were most prominent in this study, followed by changes in appetite. This is slightly different from the study by Kai et al. [40] who reported that more patients had changes in appetite (49.5%) than swallowing disturbances (22.2%).

4.5. Limitations

There are several limitations to this study. First, although the MNA-SF and MNA are well validated screening tools for malnutrition, we found no acceptable discriminative ability in our dementia patients. This may reflect a possible limitation in the design of the battery that included neuropsychiatric assessments and other self-reported scores that may have been highly individualized, thereby resulting in bias in the dementia population. Dementia is a complex and multifactorial disease, and various eating behavior and neuropsychological problems may occur in the course of the disease leading to the risk of malnutrition. Various eating problems can occur during different stages of the disease, i.e. forgetting whether they have already eaten so that they eat again, forgetting to eat, and refusal to eat. All patients diagnosed with dementia are at risk of malnutrition, and the MNA and MNA-SF may not be ideal screening tools to assess the nutritional state in all stages of dementia. In the future, a stepwise screening tool combining questionnaires and management guidelines may help to eliminate these possible confounders. Nonetheless, this study used an available battery and established a cutoff value to detect obesity. Second, most of our patients were diagnosed with AD at a very mild or mild stage (64.9% CDR .5 and 24.9% CDR 1), so the results may not be applicable to the general dementia population. The MMSE average score was 17.7 in our study, which may have been driven by the educational

level (illiterate 23%, [n = 79]; <7 years, 37.6% [n = 129]). Finally, there were many possible confounding factors, and it was not possible to include them all for analysis. Dynamic changes in dementia in terms of symptom progression and functional decline would also affect the outcomes measured in this study population, which could be overcome in future studies with a longitudinal cohort.

5. Conclusion

In conclusion, the MNA, MNA-SF and BMI were highly correlated in the patients with early stage dementia. Although the MNA (MNA-SF) was initially designed as a screening instrument to detect patients at risk of malnutrition, our study suggests that it can also be used to detect obesity with a proper cutoff value. The underweight and over-weight patients were associated with different factors. We suggest that a BMI ranging from 22 to 23 kg/m^2 can balance comorbidities and nutritional adequacy in patients with dementia.

Author contributions

HT Hsiao: study concept and design, data validation, statistical analyses, writing- original draft preparation and revising final manuscript; JJ Lee: proofreading manuscript; HH Chen: data acquisition; MK Wu: proofreading manuscript; CW Huang: data acquisition; YT Chang: data acquisition; CY Lien: proofreading manuscript; JJ Wang: conception and design of the study; HI Chang: proofreading manuscript; CC Chang: study design, data acquisition, writing-review & editing and refinement, supervision.

Conflict of interest

The Authors declare that there is no conflict of interest.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.clnu.2018.09.017.

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