

Associations Between Texture-Modified Food and Functional, Systemic, and Oral Health Among Older Adults

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Abstract

Background

Older adults frequently experience age-related declines in oral and swallowing function that increase the risk of dysphagia and its associated complications, such as aspiration pneumonia, malnutrition, and dehydration, and because of this, Texture-Modified Foods (TMFs) are widely used in clinical practice to facilitate safer oral intake and manage swallowing difficulties. This study examined the relationships between current dietary types and various health indicators in older adults residing in long-term care facilities in Korea.

Method

This study was conducted from March to September 2024 with older adults residing in a South Korean nursing home and an day care center. A total of 63 participants were classified into pureed/minced or regular diet groups. Key assessments included functional, systemic (sex, age, long-term care grade, activities of daily living, instrumental activities of daily living, number of medications, inbody analysis, ambulatory status, and comorbidities), and oral health status (clinical oral dryness score, tongue moisture level, tooth count, swallowing function and tongue strength).

Results

The findings delineate several salient predictors that distinguish the consumption of regular diets from texture-modified diets among older Korean adults. Specifically, lower activities of daily living scores, fewer medications, the presence of abdominal obesity, greater skeletal muscle mass, measurable tongue strength, and a higher number of remaining teeth were significantly associated with regular diet intake.

Conclusion

This study presents important evidence of correlations between TMFs and systemic and oral health variables, underscoring the clinical value of incorporating ADL, number of medications, AFR, SMI, tooth count, and tongue strength into dietary management for older adults and emphasizing the role of oral care in supporting nutritional and functional health.

Background

Aging is a physiological process involving the gradual decline of bodily functions, accompanied by various physical and psychological changes. As global population aging accelerates, attention to older adult health care is increasing. South Korea, now entering a super-aged society, faces increasing urgency to improve the quality of life of older adults.

With advancing age, oral functions deteriorate, reducing oral health-related quality of life and altering nutritional intake.¹ The oral musculature is involved in chewing, swallowing, and articulation, with the tongue's muscles playing a critical role in bolus movement. Atrophy of these muscles can reduce food intake capacity, compromise nutritional status, and diminish life satisfaction.²

Dysphagia affects approximately 8% of the global population and is increasingly prevalent with aging. Reduced masticatory function also decreases overall food intake, heightening the risk of undernutrition, infection, and various illnesses.³ As a key aspect of oral function, masticatory ability is closely associated with quality of life and mental health.

To manage dysphagia or poor mastication in older adults, texture-modified foods (TMFs) are often used instead of regular solids.⁴ TMFs are typically made by adding water to adjust texture and served softened, chopped, or blended. While they aid safe swallowing, TMFs can impact nutritional status, physical function, and overall health.⁵ Reduced palatability, texture changes, and poor visual appeal may lower meal satisfaction and promote negative eating attitudes. Studies show TMF users often have lower energy and protein intake, risking muscle loss.⁶

Oral health, though not directly dietary, is closely linked to chewing and swallowing.⁷ Softer foods may reduce chewing, accelerating muscle loss and oral decline. Studies show oral hypofunction in older adults is strongly tied to frailty and sarcopenia.⁸ Thus, the link between oral function, diet, and sarcopenia must be clarified.

However, research on diet modifications and oral health in Korean older adults is limited. Given cultural dietary differences, tailored studies are needed. This study aimed to analyze the relationship between diet and systemic/oral health in Korean long-term care residents and identify key factors influencing diet to guide effective nutritional strategies.

Methods

Participants

This study was conducted from March to September 2024 with older adults residing in a South Korean nursing home and an day care center that agreed to participate. Based on a G*Power analysis⁹, the minimum required sample size was 45; with a 10% dropout margin, the target was set at 50. A total of 68 individuals enrolled (31 nursing home, 37 day care center). After one withdrawal and three exclusions due to health issues, the final sample included 63 participants.

Examination

Three dental hygienists with over 5 years of experience assessed participants' general and oral health. Among them, two also held caregiver certifications. All received standardized training based on

measurement manuals, and a pilot test confirmed inter-rater reliability with error rates below 10%. To maintain consistency, each dental hygienist repeatedly conducted the same set of examination items throughout the study.

General and systemic characteristics

Participants' general and systemic characteristics were collected via self-reported questionnaires and institutional records, including sex, age, long-term care grade, Activities of Daily Living (ADL), Instrumental ADL (IADL), number of medications, number of illnesses InBody analysis, walking status, and systemic disease. For participants with cognitive impairment, questionnaires were completed with assistance from facility staff.

Long-term care grades, assessed by the National Health Insurance Service, ranged from levels 1 to 5 and a cognitive support grade. Lower grades indicated greater physical and cognitive dependency. For analysis, participants were grouped into three categories: grades 1–2, grades 3–4, and grade 5 plus cognitive support.

ADL was defined as the ability to perform essential activities for independent living (such as dressing, washing one's face, using the toilet, etc.), whereas IADL included more complex tasks (such as grooming, preparing meals, using transportation, etc.) reflecting higher levels of autonomy.¹⁰ It consists of a total of 15 items, and lower scores indicate higher independence.

Number of medications was categorized as those taking fewer than five medications and those taking five or more medications concurrently.

Body composition was assessed using the InBody S10 device (InBody Co., South Korea), suitable for seated or supine measurements.¹¹ Participants rested for 10–15 min to stabilize fluids. Then, Electrodes were placed on hands and feet without metal contact, using electrolyte tissues. Measurements were conducted fasting in the morning and 2 h after lunch. The following indicators were analyzed: phase angle (PA), abdominal fat ratio (AFR), visceral fat area, skeletal muscle mass index (SMI), and body mass index (BMI). Sex-specific risk variables were dichotomized as 0 (normal) or 1 (at-risk). abdominal obesity: ≥ 0.9 (men), ≥ 0.8 (women); low PA: ≤ 4.5 (men), ≤ 4.0 (women); sarcopenia: $\text{SMI} < 7.0 \text{ kg/m}^2$ (men), $< 5.7 \text{ kg/m}^2$ (women).^{12–14}

Walking status was categorized into two groups: the independent (walking unaided) or mobility-aided group (assistive devices) and the assistance-dependent (requiring help) or non-ambulatory group (unable to walk).

Systemic diseases included representative geriatric conditions such as hypertension, diabetes, dementia, osteoporosis, stroke, coronary artery disease, heart failure, chronic obstructive pulmonary disease (COPD), cancer, and Parkinson's disease. The presence and total number of comorbidities were recorded.

Oral health status

Oral health status was assessed by three trained examiners using the Clinical Oral Dryness Score (CODS), tongue moisture level, tooth count, swallowing function and tongue strength.

The CODS, based on 10 indicators, was used to assess oral dryness, with scores categorized as high risk (≥ 5), caution (3–4), or normal (≤ 2).

Tongue moisture was measured thrice using the Oral Moisture Checker (MCM Co., Japan). Values were categorized as normal (≥ 29.6), caution (28.0–29.5), or risk (≤ 27.9). Uncooperative participants were marked unmeasurable.¹⁵

The tooth count was visually examined, excluding roots or teeth with mobility grade 3. Oral condition was classified by tooth count: normal (≥ 20), caution (16–19), risk (< 16).¹⁶

Swallowing was assessed using the Modified Water Swallowing Test with 3 mL of cold water; aspiration, breathing, and voice changes were each scored 1 point, with total scores classified as normal (≤ 1) or risk (≥ 2).¹⁷

Tongue strength was measured using a tongue pressure measurement device (TPM-02, JMS Co., Ltd., Japan). The highest of three trials was recorded and classified as normal (≥ 30 kPa) or risk (< 30 kPa).¹⁸ However, due to cognitive impairment and difficulties in communication, only one participant could be assessed using the tongue pressure measurement device. Thus, the variable was dichotomized into measurable and unmeasurable groups.

Statistical analysis

TMFs were divided into two groups: Group 1 (pureed/minced) and Group 2 (regular). Pureed diets had smooth textures; minced diets included finely chopped foods; regular diets were unmodified.

Several continuous variables related to general and oral health were categorized into ordinal levels (normal, caution, risk, unmeasurable). Group comparisons were conducted using t-tests and Fisher's exact tests.

To identify factors associated with TMF, multivariate binary logistic regression analysis was performed. The dependent variable was TMFs, and the independent variables included general characteristics and oral health indicators (Table 2). To maintain interpretability despite the large number of variables, stepwise or block-wise modeling approaches were applied.

Table 2
Determinants of texture-modified food: Significant variables based on six groups

Independent variable		B	SE	Wald	<i>P</i>	OR	95% CI	
							LLCI	ULCI
(1) General characteristics	(Constant)	0.909	1.850	0.241	.623	2.481		
	ADL	-0.145	0.043	11.632	.001	0.865	0.796	0.940
	Abdominal fat ratio (ref. normal)	2.229	1.025	4.731	.030	9.286	1.246	69.183
(2) Systemic diseases	(Constant)	5.018	5.145	0.951	.329	151.060		
	Hypertension	2.087	0.861	5.871	.015	8.062	1.490	43.615
	Dementia	-1.590	0.806	3.888	.049	0.204	0.042	0.990
(3) Oral status	(Constant)	0.122	2.948	0.002	.967	1.130		
	Tongue strength (ref. unable to measure)	2.271	0.870	6.823	.009	9.693	1.763	53.290
	Tooth count	0.058	0.030	3.834	.050	1.060	1.000	1.124
(1), (2)	(Constant)	0.451	1.757	0.066	.797	1.570		
	ADL	-0.141	0.043	10.884	.001	0.869	0.799	0.945
	Number of comorbidities	2.309	0.975	5.605	.018	10.067	1.488	68.104
(1), (3)	(Constant)	-7.461	6.532	1.305	.253	0.001		
	SMI	-1.874	0.940	3.975	.046	0.154	0.024	0.969
	Tooth count	0.102	0.042	5.989	.014	1.107	1.020	1.201
	Tongue strength (ref. unable to measure)	4.122	1.903	4.692	.030	61.689	1.480	2570.844
(2), (3)	(Constant)	1.835	4.266	0.185	.667	6.267		
	Hypertension	1.729	0.833	4.307	.038	5.635	1.101	28.840
	Tooth count	0.201	0.472	6.476	.011	1.301	1.119	1.759
	Tongue strength (ref. unable to measure)	1.950	0.869	5.029	.025	7.028	1.279	38.631

Abbreviation: ADL, activities of daily living; CI, confidence interval; LLCI, lower limit of confidence interval; OR, odds ratio; SE, standard error; SMI, skeletal muscle mass index; ULCI, upper limit of confidence interval.

unable to
measure)

Abbreviation: ADL, activities of daily living; CI, confidence interval; LLCI, lower limit of confidence interval; OR, odds ratio; SE, standard error; SMI, skeletal muscle mass index; ULCI, upper limit of confidence interval.

The logistic regression analysis was structured into three primary models with sex and age included as covariates: Model 1: General characteristics and systemic health; Model 2: Systemic diseases; Model 3: Oral status (Table 2).

Subsequently, combined multivariable models were constructed by merging model categories—(1)+(2), (1)+(3), (2)+(3), and (1)+(2)+(3). In each combined model, redundant or non-contributory variables were excluded to prevent overfitting. Across seven total models, variables that remained were refined using backward elimination to identify the optimal set of predictors. Model fit was assessed using the Hosmer–Lemeshow test, and 95% confidence intervals (CIs) were calculated. All statistical analyses were conducted using IBM SPSS Statistics 25, with statistical significance set at $P < .05$.

Results

Cross-tabulation by TMFs

Cross-tabulation analysis revealed statistically significant associations between TMFs and ADL, IADL, ambulatory status, hypertension, and tongue strength. Participants in Group 1 demonstrated greater limitations in ADL, reduced mobility, and a lower rate of measurable tongue strength.

General and systemic characteristics

Table 1 presents the characteristics of the study participants based on TMFs. Sixty-three participants were included in the analysis and classified into two groups: Group 1 ($n = 22$) and Group 2 ($n = 41$). No significant differences were observed in sex distribution ($P = .455$), age ($P = .834$), and long-term care grade ($P = .192$).

The ADL scores were significantly higher in Group 1 than in Group 2 ($P = .001$), indicating lower functional independence in Group 1. Similarly, the IADL scores were higher in Group 1 than in Group 2. Medication use and the number of systemic diseases did not differ significantly between the groups ($P = .640$ and $.346$, respectively).

Regarding InBody analysis, no significant differences were found between the normal and at-risk groups in terms of PA, AFR, and SMI ($P = .521$, $.933$, and $.780$, respectively). Likewise, the BMI showed no statistically significant difference ($P = .233$).

However, the ambulatory status differed notably: approximately 87.8% of the participants in Group 2 could walk independently or use assistive devices, compared to 54.5% in Group 1 ($P = .003$). The non-

ambulatory or bedridden proportion was higher in Group 1 (45.5%) than in Group 2 (12.2%).

Regarding chronic diseases, hypertension was significantly more prevalent in Group 2 than in Group 1 ($P = .04$). No significant differences were found for diabetes ($P = .576$), dementia ($P = .129$), or Parkinson's disease ($P = .87$).

Associations between TMFs: Logistic regression analysis

Tables 2 and 3 show the multivariate logistic regression results linking TMFs with participants' characteristics, systemic diseases, and oral health. Factors affecting pureed versus regular diet intake were grouped into general characteristics, systemic diseases, and oral health indicators.

Table 3

Determinants of texture-modified food: Final binary logistic regression using selected variables

Independent variable	B	SE	Wald	P	OR	95% CI	
						LLCI	ULCI
(Constant)	-8.414	4.834	3.029	.082	0.000		
Sex (ref. woman)	2.434	1.390	3.065	.080	11.408	0.748	174.096
Age	1.135	0.921	1.520	.218	3.111	0.512	18.903
ADL	-0.207	0.083	6.210	.013	0.813	0.690	0.957
Number of medications (ref. ≤5)	-4.511	2.150	4.403	.036	0.011	0.000	0.743
Abdominal fat ratio (ref. normal)	3.527	1.553	5.157	.023	34.015	1.621	713.797
Phase angle (ref. normal)	2.812	1.481	3.605	.058	16.650	0.913	303.546
SMI (ref. normal)	-2.774	1.250	4.926	.026	0.062	0.005	0.723
Hypertension	1.380	1.049	1.730	.188	3.975	0.509	31.073
Dementia	1.208	1.150	1.104	.293	3.348	0.351	31.905
Tongue pressure (ref. unable to measure)	4.899	2.139	5.247	.022	134.101	2.028	8868.099
Tooth count	0.140	0.053	6.866	.009	1.150	1.036	1.276
Abbreviation: ADL, activities of daily living; CI, confidence interval; LLCI, lower limit of confidence interval; OR, odds ratio; SE, standard error; SMI, skeletal muscle mass index; ULCI, upper limit of confidence interval.							
<i>*P</i> < .05							

Note: Dependent variable (diet): 0 = blended diet (pureed using a blender)/minced diet (chopped into small pieces for easier chewing), 1 = regular diet (consumed in its normal form)

Using backward elimination, non-significant variables were excluded from each model (Table 2), and progressively combined models were developed. A final multivariate analysis was then conducted using all retained predictors (Table 3).

Multivariate logistic regression results revealed that ADL, number of medications, AFR, SMI, tongue strength, and tooth count were significantly associated with the likelihood of consuming a regular diet.

Specifically, each one-point increase in ADL score reduced the odds of regular diet consumption by 18.7% (OR = 0.813, $P = .013$), indicating that individuals requiring more assistance with daily activities tended to consume pureed diets. Participants taking five or more medications were much less likely to consume a regular diet compared to those taking fewer than five (OR = 0.011, $P = .036$). Conversely, individuals with abdominal obesity were significantly more likely to consume a regular diet (OR = 34.015, $P = .023$).

A low SMI (sarcopenia risk) was associated with lower odds of consuming a regular diet (OR = 0.062, $P = .026$), while each additional remaining tooth increased the odds by 15.0% (OR = 1.150, $P = .009$). Furthermore, individuals with measurable tongue strength were 134.1 times more likely to consume a regular diet than those without ($P = .022$).

Therefore, a greater likelihood of regular diet consumption was associated with lower ADL scores, taking fewer than five medications, having abdominal obesity, a normal SMI, more remaining teeth, and measurable tongue strength. In contrast, sex, age, PA, hypertension, and dementia were not significantly associated with the TMFs.

Table 1. Characteristics of the study participants based on the texture-modified food

Independent variable		Blended/minced diet (n=22) n (%), Mean±SD	General food (n=41) n (%), Mean±SD	<i>p</i> [†]
Systemic status				
Sex				.455
Men		6 (27.3)	15 (36.6)	
Women		16 (72.7)	26 (63.4)	
Age				.834
90 and over		5 (22.7)	7 (17.0)	
80–89 years old		13 (59.1)	28 (68.3)	
70–79 years old		3 (13.6)	4 (9.8)	
60–69 years old		1 (4.5)	2 (4.9)	
Long-term care grade				.192
1, 2		5 (7.9)	5 (7.9)	
3, 4		15 (23.8)	25 (39.7)	
5, non-graded		2 (3.2)	11 (17.5)	
ADL		26.9±9.98	16.66±9.26	.001
IADL		44.55±8.93	37.72±10.94	.005
Number of medications				.640
0–4		19 (86.4)	37 (90.2)	
5–7		3 (13.6)	4 (9.8)	
Number of illnesses				.346
0–3		17 (77.3)	27 (65.9)	
4–5		5 (22.7)	14 (34.1)	
InBody analysis				
Phase angle	normal	6 (28.6)	15 (71.4)	.521
	risk	14 (36.8)	24 (63.2)	
Abdominal fat rate	normal	11 (34.3)	21 (65.6)	.933
	risk	9 (33.3)	18 (66.7)	
SMI	normal	8 (24.2)	25 (75.8)	.780

	risk	12 (46.2)	14 (53.8)	
BMI		21.55±3.09	22.69±3.54	.233
Walking status				.003
Able to walk, assistive device		12 (54.5)	36 (87.8)	
Unable to walk, bedridden		10 (45.5)	5 (12.2)	
Systemic diseases				
Hypertension				.04
	No	11 (50.0)	10 (24.4)	
	Yes	11 (50.0)	31 (75.6)	
Diabetes				.576
	No	16 (72.7)	27 (65.9)	
	Yes	6 (27.3)	14 (34.1)	
Dementia				.129
No		4 (18.2)	15 (36.6)	
Yes		18 (81.8)	26 (63.4)	
Parkinson's disease				.87
No		19 (86.4)	36 (87.8)	
Yes		3 (13.6)	5 (12.2)	
Oral status				
CODS				.146
Normal		20 (90.9)	41 (100)	
Caution		1 (4.5)	0	
Risk		1 (4.5)	0	
Tongue moisture				.227
Unable to measure		4 (18.2)	2 (3.2)	
Normal		5 (22.7)	17 (41.5)	
Caution		5 (22.7)	7 (17.1)	
Risk		8 (36.4)	15 (36.6)	
Tooth count				.061

Normal	5 (22.7)	22 (53.7)
Caution	1 (4.5)	1 (2.4)
Risk	16 (72.7)	18 (43.9)
Swallowing function		0.529
Normal	24(85.7)	31(88.6)
Risk	3(10.7)	4(11.4)
Unmeasurable	1(3.6)	0(0)
Tongue strength		0.004
Able to measure	14 (63.6)	38 (92.7)
Unable to measure	8 (36.4)	3 (7.3)

Abbreviations: ADL, activities of daily living; BMI, body mass index; CODS, clinical oral dryness score; IADL, instrumental activities of daily living; SD, standard deviation; SMI, skeletal muscle mass index

Data are presented as means $\pm$ standard deviation or n (%).

[†] Chi-squared test or t-test. [†] Mann–Whitney test.

^{||} Chronic Obstructive Pulmonary Disease

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Abbreviation: ADL, activities of daily living; CI, confidence interval; LLCI, lower limit of confidence interval; OR, odds ratio; SE, standard error; SMI, skeletal muscle mass index; ULCI, upper limit of confidence

interval.

Note: Dependent variable (diet type): 0 = blended diet (pureed using a blender)/minced diet (chopped into small pieces for easier chewing), 1 = regular diet (consumed in its normal form). Only significant variables are presented, with sex and age included as control variables in all regression models.

Variable by group: (1) type of facility, long-term care grade, ambulatory status, ADL, IADL, number of medications, number of comorbidities, phase angle, abdominal fat ratio, visceral fat ratio, SMI, and body mass index; (2) hypertension, diabetes, dementia, osteoporosis, stroke, coronary artery disease, heart failure, chronic obstructive pulmonary disease, cancer, and Parkinson's disease; (3) tongue moisture, tongue strength, tooth count and swallowing function

Discussion

This study analyzed factors influencing TMF in older adults in Korean long-term care. Analysis of systemic and oral health variables identified ADL, number of medications, AFR, SMI, tongue strength, and tooth count as key determinants. These findings suggest that maintaining oral function significantly impacts the overall health of older adults and that an integrated approach combining oral function support and nutritional management is essential.

Among the variables, ADL showed a strong association with TMF. ADL is consistently linked to oral and systemic health. Previous studies reported correlations between nutritional status, cognitive function, oral health, and swallowing ability, and found that improving oral condition could enhance swallowing and lower ADL scores, thereby supporting functional independence.^{19,20} In this study, higher ADL scores were linked to lower chances of eating a regular diet, with each point increase reducing odds by 0.894 times. This indicates that decreased functional independence leads to greater reliance on TMFs. These findings underscore the interrelationship between swallowing function and frailty, suggesting that declines in ADL may reflect not only physical deterioration but also broader impairment in oral and swallowing functions. Reduced capacity for ADL may indicate oral functional decline beyond physical impairment, and preserving swallowing ability may help prevent ADL decline and support independence.

According to the regression analysis, participants taking five or more medications were more likely to consume a pureed diet than a regular diet. In older adults, the number of medications often increases inevitably due to biological aging and the management of multiple chronic conditions. Although there is no universally standardized definition of polypharmacy, many studies define it as the use of five or more medications.²¹ Systematic reviews have demonstrated a strong positive correlation between polypharmacy and frailty.²² Moreover, a previous study reported that taking seven or more medications was associated with a 2.5-fold increased risk of developing frailty over eight years. These findings underscore the critical role of polypharmacy in the development of frailty. In addition, earlier studies reported a significant negative correlation between the number of medications and the intake of dietary fiber and vitamins. Other studies have suggested that polypharmacy contributes to cognitive decline, as

well as to a range of oral health problems.²³ These findings highlight caution in multiple medication use among older adults.

In older adults, abdominal obesity is often considered a marker of metabolic disorders. However, in frail older adults, weight and fat mass typically decline together, making abdominal fat a potential indicator of adequate nutritional status and energy reserves. Some studies have reported that mild to moderate adiposity in older adults can be protective, lowering mortality and morbidity.²⁴ Moreover, oral health issues can reduce appetite or impair chewing, triggering “anorexia of the elderly,” which may progress to malnutrition. Common markers of malnutrition include weight loss due to fat depletion and sarcopenia. Participants with more abdominal fat and no sarcopenia were likelier to eat a regular diet, supporting prior evidence that these individuals tend to have better overall nutritional status and a greater ability to maintain regular dietary intake. Additionally, since all participants in this study resided in long-term care facilities, it is likely that they received some degree of nutritional management, and thus, factors other than diet may have played a more significant role in abdominal fat accumulation.

The SMI, a well-established marker of overall muscle mass and nutritional status, is also associated with weakening of tongue muscles. Sarcopenia can impair swallowing muscles, causing dysphagia, and tongue pressure testing is proposed as its clinical indicator.²⁵ Low tongue pressure is associated with an increased risk of aspiration pneumonia and malnutrition, prompting ongoing research in this area. In this study, participants whose tongue strength could be measured were significantly more likely to consume a regular diet than those for whom measurement was not possible. Inability to measure tongue strength may reflect broader oral and swallowing decline beyond muscle weakness. While tongue atrophy isn't the only cause of dysfunction or poor nutrition, tongue muscle exercise aids recovery and helps prevent sarcopenia.²⁶ Previous studies have demonstrated that oral function training aimed at maintaining or improving feeding ability led to improved nutritional status among older adults. Therefore, oral exercises and rehabilitation focused on enhancing tongue strength may help improve dietary intake and overall quality of life among older adults.

Masticatory function is closely associated with tooth loss, which not only reduces chewability but also leads to qualitative changes in dietary intake. As the tooth count decreases, the occlusal surface area is reduced, leading to a shift from fiber- and protein-rich foods to softer, carbohydrate-based diets, while weakened mandibular stability impairs swallowing function.^{6,27} This shift can contribute to nutritional imbalance and declining systemic health. Reduced chewing was also associated with low ADL, cognitive decline, depression, and malnutrition.⁷ In this study, the odds of consuming a regular diet increased by 1.1 times with each additional remaining tooth, highlighting the impact of oral health on TMF and its broader nutritional implications. According to research^{28, 29} severe tooth loss or chewing and swallowing difficulties restrict food choices in older adults, leading to nutritional deficiencies, frailty, and sarcopenia. Sarcopenia, commonly observed during aging, refers to the pathological decline in muscle mass and function. Age-related sarcopenia may suppress appetite or reduce protein synthesis, thereby limiting physical activity in older adults and eventually increasing the risk of frailty, disability, and mortality. To mitigate these risks and promote healthy aging, a comprehensive approach is needed—one that supports

the maintenance and recovery of oral function and encourages physical activity to help prevent the onset and progression of sarcopenia.

This study had some limitations. The cross-sectional design prevented identification of changes over time or the establishment of causality. Although indicators such as SMI and nutritional status are useful, they are not sufficient to fully explain the association with TMF. It is important to recognize that the effects of TMF on overall muscle mass may vary depending on factors such as hydration status, nutrient absorption, and metabolism.³⁰ Moreover, due to the observational design, limited sample size, and specific study population, findings may not generalize to broader populations.

Conclusion

This study provides important evidence supporting correlations between TMFs and systemic and oral health variables. The findings hold clinical significance, as they emphasize the importance of considering the ADL, number of medications, AFR, SMI, tooth count, and tongue strength in the dietary management of older adults, and they highlight the role of oral care in supporting nutritional and functional health.

Future research should include prospective studies to evaluate the effectiveness of intervention programs targeting these key factors. More detailed classifications of TMFs and longitudinal follow-up are also needed to clarify causal relationships. Such efforts may contribute to the development of more effective nutritional management strategies aimed at improving the health and quality of life of individuals with dysphagia.

Declarations

Ethics approval and consent to participate

The study was conducted in accordance with the principles of the Declaration of Helsinki. The study was approved by the Institutional Review Board of Cheongju University (Approval No. 1041107-202312-BR-052-01). Written informed consent to participate was obtained from all individual participants included in the study, and for those with cognitive impairment who were unable to provide consent, written consent was obtained from their legally authorized guardians.

Consent for publication

Not applicable

Availability of data and materials

The data are not publicly available due to the inclusion of sensitive personal information of the subjects, which cannot be disclosed.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

Conceptualization, HN; Methodology, HN, NY, HK, JW; Writing—original draft, NY, HK; Investigation, HN, NY, HK; Data curation, NY, HK; Supervision, HN; All authors read and approved the final manuscript.

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