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Association and relevant factors between objective masticatory performance and subjective masticatory ability among community-dwelling older adults

Feng-I Chen [a,b], Jen-Hao Chen [a,b,c], Jiiang-Huei Jeng [a,d,e], Sumio Akifusa [f], Hsiu-Yueh Liu [g,h,i*]

[a] School of Dentistry, College of Dental Medicine, Kaohsiung Medical University, Kaohsiung, Taiwan
[b] Division of Prosthodontics, Department of Dentistry, Kaohsiung Medical University Hospital, Kaohsiung, Taiwan
[c] Department of Dentistry, Kaohsiung Municipal Siaogang Hospital, Kaohsiung, Taiwan
[d] Department of Dentistry, Kaohsiung Medical University Hospital, Kaohsiung, Taiwan
[e] Department of Dentistry, National Taiwan University Hospital, Taipei, Taiwan
[f] School of Oral Health Sciences, Faculty of Dentistry, Kyushu Dental University, Kitakyushu, Fukuoka, Japan
[g] Department of Oral Hygiene, College of Dental Medicine, Kaohsiung Medical University, Kaohsiung, Taiwan
[h] Center for Long-Term Care Research, Kaohsiung Medical University, Kaohsiung, Taiwan
[i] Department of Medical Research, Kaohsiung Medical University Hospital, Kaohsiung, Taiwan

Abstract *Background/purpose:* Dentists often focus on masticatory performance (MP) rather than masticatory ability (MA) and treatment expectations when evaluating older adults. This study aimed to determine if MA aligns with MP and to explore influencing factors.
Materials and methods: This cross-sectional study utilized a multi-stage stratified cluster sampling, including one thousand community-dwelling adults aged 60 and older. Participants underwent oral exams and questionnaire interviews, assessing tooth count and Eichner index (EI) levels. MP and MA were quantified using a standard gummy jelly test and a 14-food group questionnaire, respectively. Multivariable linear regressions analyzed correlations between MP, MA, and related factors.
Results: Approximately 25 % of participants exhibited poor MP. Factors contributing to poor MP included increased age rise, low education, number of chronic diseases, tooth loss, without the

* Corresponding author. Department of Oral Hygiene, College of Dental Medicine, Kaohsiung Medical University, No. 100 Shih-Chuan 1st Road, San Ming District, Kaohsiung 80708, Taiwan.
E-mail address: hyliu@kmu.edu.tw (H.-Y. Liu).

assistance of removable dentures, and being in EI group C (all $P < 0.05$). Tooth count showed a significant negative correlation with MP ($P < 0.001$). Participants' MP declined significantly from good to poor, with MA scores decreasing from 11.96 to 7.52 ($P < 0.001$). The tooth number was a common factor influencing MA across food groups (all $P < 0.05$). The decline in MA among older adults was linked to age rise, tooth loss, lack of assistance of removable dentures, and being in EI group C.

Conclusion: Self-rated MA in older adults effectively reflects their MP. Maintaining a high tooth count to meet occlusal support and the use of dentures to assist with tooth loss in older adults help to improve their MA.

Introduction

Chewing is the process of repeatedly opening and closing the jaw and grinding food ingested into small particles with the teeth for subsequent swallowing and digestion.[1] For older adults, having 20 or more teeth and maintaining at least eight functional tooth units is essential to maintain chewing function and a balanced nutritional intake.[2−4] In Taiwan, 36.6 % of the participants aged 65 years or older have fewer than 20 natural teeth.[5] Oral diseases such as caries and periodontitis may cause tooth loss. The result of tooth loss is usually a decrease in chewing function. Decreased chewing function affects the variety of food intake in older adults, reducing the desire for food intake and leading to malnutrition.[6,7] Enhancement of masticatory function is one of the main goals of oral function reconstruction in older adults.

Chewing function assessment helps the dentist to understand the status of a person's chewing function and prepares the patient for successful oral function enhancement. Color-changing chewing gums, sieves and soft candies are considered to be objective methods of masticatory performance (MP) assessment as they have shown good reliability and validity in the past.[8,9] These methods are often used to objectively assess the ability to mix and crush specific types of food during chewing. In recent years, many countries have successfully developed their own self-perceived food intake questionnaires for assessing subjective masticatory ability (MA) based on everyday foods in their countries. The 14-food group questionnaire is now considered the best screening test for MA in Taiwan.[4] It is comprised solely of hard or tough foods and is divided into three subcategories: vegetables, fruits, and seafood and meats. The questionnaire's substantial classification capability (AUC = 0.8294) for distinguishing MA grades was validated by 2244 older adults.[4]

While improving chewing function, the eating habits and needs of the older adults need to be taken into consideration. Objective assessment methods produce accurate information and are relatively dependent on specialized manpower and equipment.[10] In contrast, subjective methods not only have the advantage of being less costly, but are also easy to screen large populations in the community. This makes it difficult to choose between objective and subjective assessment when reconstructing dental function. Furthermore, past studies have observed a lack of consistency between objective and subjective assessment methods in young populations.[11,12] Therefore, this study primarily aimed to examine whether older adults' self-perceived chewing abilities are consistent with their chewing performance results. The second aim was to explore factors that influence older adults' perceived chewing ability when consuming different types of food.

Materials and methods

Study design and participants

This cross-sectional study included one thousand community-dwelling older individuals aged 60 years and over (average age 73.26 ± 7.60 years old). This study required participants to have no underlying cognitive impairment or mental disorders. Participants were excluded from this study they had conditions such as neuromuscular disease, head and neck cancer, craniofacial malformations, or syndromic diseases affecting oral function. Vegetarians who did not satisfy all of the food requirements and could not complete the survey were excluded.

Sample size calculation

The survey sampled 616,280 community-dwelling older individuals. We suggested estimating the population proportion that yields the largest sample size with the most variances when p approaches 0.50. According to Krejcie and Morgan, using the Slovin or Yamane calculation, a study should have 384 participants at 95 % confidence and a 5 % margin of error.[13,14] The optimal sample size for this study was 998 after factoring in a 30 % drop-out rate and a double sample size. The sample size was increased to one thousand for subsequent sampling.

Sampling

Kaohsiung's 38 districts were reorganized into urban (eight districts), town (nine districts), and rural (21 districts) clusters using Taiwan's township typology.[15] Multi-stage stratified cluster sampling recruited participants from urban, town, and rural clusters with 47.76 %, 31.39 %, and 20.65 % probability, respectively, and randomly selected care centers depending on size. Four hundred and sixty-three, 339, and 198 suitable individuals were recruited from 19 urban, 12 town, and seven rural clusters,

respectively. The one thousand older adults (215 men and 785 women) completed the study's assessments.

Ethical approval

The study was authorized by the Institutional Review Board (IRB—F(I)—20190104). All procedures followed the institutional and/or national research committee's ethical requirements and the 1964 Helsinki Declaration and its later revisions or comparable ethical standards. Before oral exams and assessments, participants signed informed permission after the goal, advantages and hazards, confidentiality, and withdrawal options were explained to them.

Objective dental examination and assessment

Three well-trained senior dentists examined the participants while they were seated according to the World Health Organization's criteria.[16] The kappa coefficient for decay of the teeth was 0.81. With enough natural light, no radiography, and the use of disposable dental mirrors and CPI explorers, all oral examinations were conducted.

Dentists counted each participant's remaining natural teeth, fixed artificial teeth, complete and removable partial dentures. Those teeth with mobility grade III, residual roots, or extensive crown destruction (i.e., more than three-fourths of the clinical crown destroyed) were excluded from the study. The teeth ranged from 0 to 28, except for the third molars.[4] The modified Eichner index (EI) classification, a validated measure based on the number of teeth that are now functioning and occlusal contact in the premolar and molar areas, was used to assess occlusal support.[17—19] Three groups based on the EI categorization were identified: A group had four posterior supporting zones, B group had one to three posterior supporting zones or anterior occlusal contacts, and C group had no occlusal contact on any of the remaining teeth.

The MP was assessed using a 5.5 g standard test gummy jelly (UHA Mikakuto Co., Ltd., Osaka, Japan) through a visual scoring procedure that provided an objective and quantitative evaluation.[20] Participants were directed to chew a gummy jelly for 30 cycles without swallowing and then spit it out into a white disposable paper dish. The fragmented sections were evaluated using a visual scoring table, which corresponds to a one-to-one ratio, and categorized into 10 levels (ranging from 0 to 9). A higher score indicates a superior MP quality. In the field of statistics, the MP score was categorized into three levels based on the quartile of MP scores: bad, with a score ranging from 0 to 2; moderate, with a score ranging from 3 to 6; and good, with a score ranging from 7 to 9.

Subjective data collections

The data was collected by well-trained interviewers using face-to-face interviews and a standardized questionnaire. The structured questionnaire included demographic data such as age, gender, and education level, as well as medical history.

MA was assessed using a 14-food group intake questionnaire specifically designed for daily Taiwanese food.[4] The questionnaire encompasses several food textures, such as hardness, viscosity, fracture ability, and chewiness. It comprises five vegetables (stir-fried peanut, boiled sweet corn on the cob, sliced cucumber or kidney bean, boiled bamboo shoots or broccoli, and boiled white radish or carrot), five fruits (sliced guava, sugar cane (not juice), sliced apple or pear, sliced orange, and sliced star fruit or bell fruit), and four types of meat and seafood (squid, soy sauce-braised pork ears, fried chicken leg or chicken fillet, and grilled calamari or soy sauce-braised chicken gizzard). The participants were given three choices within each food group: 'easy to chew,' 'difficult tough to chew,' and 'hard to chew'. The participants individually assessed each food item and chose the one that best matched their ability to chew. The participants' MA was assessed based on the quantity of food that was easy for them to eat. MA scores ranged from 0 to 14, with higher values indicating more easily chewed food and better MA.

Statistical analysis

The statistics software (IBM SPSS Statistics, v20.0; IBM Corp., Armonk, NY, USA) was used for both descriptive and inferential statistical analysis. Percentages were used to show the distribution of research category data. The differences in participant characteristics based on gender and MP were compared using the chi-square test and Fisher's exact test. The t-test and ANOVA were used to compare the MA score between or among different participant characteristics. The factors associated with MP were identified using multivariable linear regression analysis, which also produced the best explanatory models of the factors that helped MA on different food types. A 5 % significance threshold and a 95 % confidence interval were used for each statistical test.

Results

The average age of males (74.75 ± 7.51) was significantly greater than that of females (72.86 ± 7.58) ($P = 0.001$). The percentage of males (32.56 %) with a college education or above was much more than that of females (12.36 %). There was no statistically significant difference between males and females in terms of the number of chronic diseases, number of teeth, use of removable dentures, EI groups, MP, or food intake score (Table 1).

There was a strong and statistically significant correlation between poor MP and low education level, a lower number of teeth, and being in EI group C (all $P < 0.01$). There was a statistically significant negative connection between age increasing, having more chronic conditions, and using removable dentures with MP (all $P < 0.05$) (Table 2). The multivariable linear regression analysis found that older age, lower education level, and fewer teeth are statistically significant factors associated with a low MP in older persons (Table 3).

The participants with good MP had a statistically significantly higher MA score (11.96) than those with moderate and poor MP (10.66 and 7.52) ($P < 0.001$) (Table 4). The multivariable linear regression analysis in the adjusted model revealed that age, tooth number, removable denture

Table 1 Characteristics of participants.

Variable	All		Male		Female		P-value
	n	(%)	n	(%)	n	(%)	
Age group							
60—64 years old	132	(13.20)	15	(6.98)	117	(14.90)	0.006
65—69 years old	261	(26.10)	48	(22.33)	213	(27.13)	
70—74 years old	222	(22.20)	53	(24.65)	169	(21.53)	
75—79 years old	181	(18.10)	41	(19.07)	140	(17.83)	
80—84 years old	119	(11.90)	33	(15.35)	86	(10.96)	
≥85 years old	85	(8.50)	25	(11.63)	60	(7.64)	
Education							
Illiterate	145	(14.50)	4	(1.86)	141	(17.96)	<0.001
Elementary school	354	(35.40)	65	(30.23)	289	(36.82)	
Junior or senior high school	334	(33.40)	76	(35.35)	258	(32.87)	
College or above	167	(16.70)	70	(32.56)	97	(12.36)	
Number of chronic diseases							
0	322	(32.20)	68	(31.63)	254	(32.36)	0.553
1	363	(36.30)	73	(33.95)	290	(36.94)	
≥2	315	(31.50)	74	(34.42)	241	(30.70)	
Number of teeth							
0-9	236	(23.60)	48	(22.33)	188	(23.95)	0.485
10-19	186	(18.60)	46	(21.40)	140	(17.83)	
≥20	578	(57.80)	121	(56.28)	457	(58.22)	
Removable denture use							
No	802	(80.20)	178	(82.79)	617	(78.60)	0.334
Yes	198	(19.80)	37	(17.21)	161	(20.51)	
Eichner index group							
A	380	(38.00)	75	(34.88)	305	(38.85)	0.413
B	363	(36.30)	86	(40.00)	277	(35.29)	
C	257	(25.70)	54	(25.12)	203	(25.86)	
Masticatory performance							
Good	253	(25.30)	50	(23.26)	203	(25.86)	0.587
Moderate	354	(35.40)	82	(38.14)	272	(34.65)	
Poor	393	(39.30)	83	(38.60)	310	(39.49)	

use, and EI group were the primary factors influencing the MA of older persons (Table 5). The participants who utilized detachable dentures experienced a significant increase in their MA scores for vegetable and fruit intake, with increments of 0.61 and 0.6, respectively (all $P < 0.01$). Additionally, the participants in EI group A were statistically significantly more likely to have a higher MA to consume fruits, meats, and seafood as compared to those with an EI of C ($P < 0.001$ and $P = 0.018$), respectively.

Discussion

This study provides evidence for the consistency between older people's perceived MA and objective MP. MP of all participants was assessed using the same validated gummies, and they also provided self-reported information on their MA. The study's findings indicate that the number of teeth serves as the foundation for both MP and MA. As food texture changes, the MA of the participant reflects needs other than tooth number, such as dentures and occlusion. When older adults feel they can eat less food, this reflects a decrease in their MP. This may help dentists understand the eating habits and chewing needs of older adults and provide appropriate treatment for them.

Advanced age, limited education, and a higher number of chronic illnesses are factors that increase the likelihood of MA deterioration in older adults. This finding is consistent with earlier studies showing that those with less than 20 teeth or 8 teeth units generally have characteristics of advanced age and lower educational attainment.[4] The participants with higher education levels possess a greater awareness of oral health care and may proactively preserve oral health to retain more teeth.[15] Despite controlling for age, gender, and education in the logistic regression analysis, this study discovered that both MP and MA still decline as age increases by one year. Mastication is a highly intricate process within the human body. The coordinated movement state is established by the interaction of bones, temporomandibular joints, teeth, and muscles. Prior research has indicated that as people age, their tongue muscles lose power and their ability to move their lips and tongue fast also decreases. MP and MA are negatively impacted by this degradation.[15,21] As a result of reduced tongue pressure, older people typically select softer foods and take longer to finish their meals than they did in the past.[15] According to 67.8 % of the senior participants in this survey, they had at least one chronic illness and regularly took medications. Previous epidemiological research has shown that the use of

Table 2 Characteristics of participants according to masticatory performance.

Variable	All		Poor		Moderate		Good		P-value
	n	(%)	n	(%)	n	(%)	n	(%)	
Age group									
60—64 years old	132	(13.20)	13	(9.85)	37	(28.03)	82	(62.12)	<0.001
65—69 years old	261	(26.10)	40	(15.33)	88	(33.72)	133	(50.96)	
70—74 years old	222	(22.20)	49	(22.07)	90	(40.54)	83	(37.39)	
75—79 years old	181	(18.10)	53	(29.28)	74	(40.88)	54	(29.83)	
80—84 years old	119	(11.90)	51	(42.86)	36	(30.25)	32	(26.89)	
≥85 years old	85	(8.50)	47	(55.29)	29	(34.12)	9	(10.59)	
Education									
Illiterate	145	(14.50)	64	(44.14)	52	(35.86)	29	(20.00)	<0.001
Elementary school	354	(35.40)	119	(33.62)	134	(37.85)	101	(28.53)	
Junior or senior high school	334	(33.40)	50	(14.97)	125	(37.43)	159	(47.60)	
College or above	167	(16.70)	20	(11.98)	43	(25.75)	104	(62.28)	
Number of chronic diseases									
0	322	(32.20)	61	(18.94)	116	(36.02)	145	(45.03)	0.014
1	363	(36.30)	98	(27.00)	127	(34.99)	138	(38.02)	
≥2	315	(31.50)	94	(29.84)	111	(35.24)	110	(34.92)	
Number of teeth									
0-9	236	(23.60)	157	(66.53)	60	(25.42)	18	(7.63)	<0.001
10-19	186	(18.60)	60	(32.26)	88	(47.31)	39	(20.97)	
≥20	578	(57.80)	36	(6.23)	206	(35.64)	336	(58.13)	
Removable denture use									
No	802	(80.20)	122	(15.21)	304	(37.91)	376	(46.88)	<0.001
Yes	198	(19.80)	131	(66.16)	50	(25.25)	17	(8.59)	
Eichner index group									
A	378	(37.80)	17	(6.72)	121	(34.18)	240	(61.07)	<0.001
B	363	(36.30)	66	(26.09)	166	(46.89)	131	(33.33)	
C	259	(25.90)	170	(67.19)	67	(18.93)	22	(5.60)	

Table 3 Multivariable analysis of factors affecting masticatory performance.

Variable	β	SE	t Ratio	P	95 % CI
					(Lower, Upper)
Age (years)	−0.04	0.01	−3.74	<0.001	(−0.06, −0.02)
Gender					
Female (vs male)	−0.04	0.19	−0.23	0.821	(−0.41, 0.32)
Education					
Illiterate (vs college or above)	−0.75	0.29	−2.55	0.011	(−1.33, −0.17)
Elementary school (vs college or above)	−0.42	0.23	−1.81	0.070	(−0.87, 0.03)
Junior or senior school (vs college or above)	−0.08	0.22	−0.35	0.729	(−0.50, 0.35)
Teeth	0.17	0.01	21.25	<0.001	(0.16, 0.19)

CI: confidence interval. Adjusted participants' gender and age. $R^2 = 0.43$.

many medications to manage chronic conditions significantly increases the chance of MP deterioration.[22]

Having more teeth, wearing removable dentures, and more occlusal support can help demonstrate high MP to increase subjective perceived MA. Retaining more teeth is fundamental to maintaining optimal MP.[23] In this study, participants in the EI group C had the worst MP compared with the other two groups. Occlusal force, i.e. the performance of occlusal support, has been a common factor in MP and MA evaluations in the past. The practice of oral health care, including daily cleanliness routines and frequent dental check-ups, allows older individuals to maintain good oral hygiene and retain a greater number of their teeth. Oral health education informs older adults about the significance of dental health for their overall well-being and encourages them to improve their dental condition. MP is a comprehensive oral motor function represented by tongue muscle strength. Without the function of the muscles of mastication, and the teeth that transmit muscle force to the food, MP would not perform well.[11] Although people generally do not use their maximum bite force when chewing habitually. The bite

Table 4 Characteristics of participants according to the masticatory ability by food types.

Variable	All foods Mean	SD	P-value	Vegetables Mean	SD	P-value	Fruits Mean	SD	P-value	Seafoods and meats Mean	SD	P-value
Gender												
Male	10.09	4.55	0.270	3.99	1.62	0.212	3.59	1.64	0.211	2.52	1.60	0.547
Female	10.46	4.21		4.13	1.48		3.73	1.47		2.59	1.59	
Age group												
60–64 years old	11.99	3.29	<0.001	4.55	1.11	<0.001	4.20	1.23	<0.001	3.24	1.21	<0.001
65–69 years old	11.69	3.26		4.52	1.05		4.16	1.10		3.00	1.42	
70–74 years old	10.33	4.21		4.10	1.51		3.68	1.48		2.55	1.61	
75–79 years old	9.64	4.41		3.90	1.60		3.46	1.53		2.29	1.60	
80–84 years old	9.08	4.71		3.73	1.69		3.25	1.72		2.10	1.67	
≥85 years old	7.38	5.20		3.06	2.00		2.67	1.85		1.65	1.65	
Education												
Illiterate	9.10	4.77	<0.001	3.68	1.72	<0.001	3.28	1.67	<0.001	2.14	1.71	<0.001
Elementary school	9.90	4.50		3.96	1.61		3.56	1.57		2.38	1.66	
Junior or senior high school	11.02	3.85		4.30	1.32		3.90	1.37		2.81	1.48	
College or above	11.23	3.81		4.37	1.33		3.95	1.37		2.91	1.44	
Number of chronic diseases												
0	11.04	4.03	0.002	4.25	1.40	0.060	3.91	1.46	0.009	2.88	1.48	<0.001
1	10.18	4.29		4.06	1.53		3.63	1.49		2.50	1.60	
≥2	9.93	4.46		3.99	1.59		3.57	1.56		2.37	1.65	
Number of teeth												
0–9	7.75	4.87	<0.001	3.26	1.90	<0.001	2.77	1.73	<0.001	1.72	1.61	<0.001
10–19	8.98	4.61		3.68	1.72		3.23	1.64		2.07	1.60	
≥20	11.90	3.09		4.58	0.97		4.23	1.06		3.09	1.37	
Removable denture use												
No	10.97	3.95	<0.001	4.27	1.37	<0.001	3.91	1.38	<0.001	2.78	1.53	<0.001
Yes	8.00	4.73		3.41	1.82		2.83	1.69		1.76	1.58	
Eichner index group												
A	12.45	2.52	<0.001	4.74	0.78	<0.001	4.38	0.88	<0.001	3.33	1.17	<0.001
B	10.16	4.10		4.04	1.46		3.69	1.44		2.43	1.60	
C	7.67	4.94		3.25	1.91		2.73	1.76		1.69	1.61	
Masticatory performance												
Poor	7.52	4.93	<0.001	3.15	1.91	<0.001	2.68	1.75	<0.001	1.69	1.60	<0.001
Moderate	10.66	3.96		4.21	1.37		3.84	1.39		2.60		
Good	11.96	3.02		4.61	0.96		4.23	1.06		3.13		

force provided by the bite support may still be part of the changes in MP during chewing, especially for foods that are physically hard, rubbery, and/or tough.[12,24] Oral or masticatory exercises will substantially assist older adults in averting the decline of MA, thus improving and preserving their oral functions.[25]

In this study, the visual jelly method was used for objective MP assessment. A quarter of the participants were categorized as having poor MP. This result is marginally higher than the 21.8 % discovered in a prior Japanese study.[26] In the low MP group, nearly 70 % (66.53 %) of the participants had less than 10 teeth, and 83.43 % of them used dentures to assist with eating. The use of dentures increases the number and area of occlusal contacts, which can improve MP and enhance MA.[10] Even when teeth are replaced with removable dentures, the loss of occlusal contact still results in a decrease in occlusal force and MP.[27]

Participant MAs facing food items with different chewing difficulties can well distinguish the severity of tooth loss and denture status. In this study, participants with poor MP felt that only 53.71 % of the 14 daily food groups in their MA were easy to eat. Vegetables are considered the simplest food to eat (63 %), whereas seafood and meat (42.25 %) are thought to be the hardest. Vegetables are fibrous and soft and can be cooked into easy-to-eat meals by pre-chopping and extending the cooking time. It is known from the MA of the participant that the use of dentures can compensate for the ability of a few teeth to eat vegetables. Grating of hard fruits depends on moderate MP. Even though the fruit is cut into slices, dentures can only handle a small portion of hard foods, and the rest of the MP depends on occlusal contacts. It goes without saying that occlusal support is crucial for crushing and grinding raw meats and seafood. Food groups with a variety of physical properties can not only present a participant's MA well but also fully reveal the impact of the number of teeth, wearing of dentures, and occlusal support on MA. That is, the 14-food group questionnaire is a convenient screening tool suitable for use in the assessment of MA in community-dwelling older adults. Food groups with a variety of physical properties not only provide a good representation of a participant's MA but also fully reveal the effects of the number of teeth, use of dentures, and occlusal support on MA.

Table 5 Multivariable analysis of factors affecting masticatory ability.

Variable	β	SE	t Ratio	P-value	95 % CI (Lower, Upper)	R²
All foods						
Age (years)	−0.08	0.02	−4.86	<0.001	(−0.12, −0.05)	0.23
Gender						
Female (vs male)	0.06	0.29	0.21	0.834	(−0.51, 0.63)	
Teeth	0.12	0.03	4.07	<0.001	(0.06, 0.18)	
Removable denture use						
Yes (vs no)	1.85	0.56	3.30	0.001	(0.75, 2.95)	
Eichner index group						
A (vs C)	2.82	0.79	3.57	<0.001	(1.27, 4.37)	
B (vs C)	1.70	0.65	2.62	0.009	(0.43, 2.96)	
Vegetables						
Age (years)	−0.03	0.01	−4.63	<0.001	(−0.04, −0.02)	0.18
Gender						
Female (vs male)	0.03	0.11	0.30	0.761	(−0.18, 0.24)	
Teeth	0.07	0.01	10.09	<0.001	(0.06, 0.08)	
Removable denture use						
Yes (vs no)	0.61	0.17	3.68	<0.001	(0.29, 0.94)	
Fruits						
Age (years)	−0.03	0.01	−4.44	<0.001	(−0.04, −0.02)	0.22
Gender						
Female (vs male)	0.05	0.10	0.48	0.632	(−0.15, 0.25)	
Teeth	0.04	0.01	3.77	<0.001	(0.02, 0.06)	
Removable denture use						
Yes (vs no)	0.60	0.20	3.03	0.003	(0.21, 0.99)	
Eichner index group						
A (vs C)	1.01	0.28	3.60	<0.001	(0.46, 1.56)	
B (vs C)	0.70	0.23	3.06	0.002	(0.25, 1.15)	
Seafood and meats						
Age (years)	−0.03	0.01	−4.52	<0.001	(−0.04, −0.02)	0.19
Gender						
Female (vs male)	−0.03	0.11	−0.26	0.794	(−0.25, 0.19)	
Teeth	0.03	0.01	2.99	0.003	(0.01, 0.05)	
Eichner index group						
A (vs C)	0.66	0.28	2.38	0.018	(0.12, 1.21)	
B (vs C)	0.10	0.21	0.47	0.636	(−0.31, 0.51)	

CI: confidence interval. Adjusted participants' gender and age.

Several ethnic groups inhabit Taiwan, which is characterized by its diverse culture. Various races may exhibit distinct MA and MP levels. Due to the absence of racial data in this study, it is unfeasible to ascertain potential disparities in MA among other racial groups in this context. All participants in this study were evaluated based on their daily dietary status over the past 6 months. This includes people with complete dentures and partial dentures. Denture quality and the number of years the participant had used complete and partial dentures determined the uncertain likelihood of interference with MP and/or MA. To shed light on the effects of denture usage on MP and MA, it will be required to incorporate in the future the duration and stability of denture use experience.

This study demonstrates that the older adults' subjective MA can accurately reflect their MP. The quantity of teeth is a prevalent determinant of MP and MA. The requirements of the older adults in terms of the number of teeth, the use of dentures, and occlusal support when consuming various food categories are revealed in full by MA.

Declaration of competing interest

The authors have no conflicts of interest relevant to this article.

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References

1. Layton DM, Morgano SM, Muller F, et al. Glossary of prosthodontic terms 2023: tenth edition. *J Prosthet Dent* 2023;130: e7—126.
2. Sato Y, Ishida E, Minagi S, Akagawa Y, Tsuru H. The aspect of dietary intake of full denture wearers. *Nippon Hotetsu Shika Gakkai Zasshi* 1988;32:774—9.
3. Yamamoto S, Shiga H. Masticatory performance and oral health-related quality of life before and after complete denture treatment. *J Prosthodont Res* 2018;62:370—4.
4. Hsu KJ, Lee HE, Lan SJ, Huang ST, Chen CM, Yen YY. Evaluation of a self-assessed screening test for masticatory ability of Taiwanese older adults. *Gerodontology* 2012;29: e1113—20.
5. Chi LY. *Oral health survey for adults and older adults in Taiwan*. Taipei, Taiwan: Ministry of Health and Welfare, Department of Oral Health, Executive Yuan, 2023.
6. Nguyen TC, Witter DJ, Bronkhorst EM, Gerritsen AE, Creugers NH. Chewing ability and dental functional status. *Int J Prosthodont (IJP)* 2011;24:428—36.
7. Emami E, Allison PJ, de Grandmont P, Rompré PH, Feine JS. Better oral health related quality of life: type of prosthesis or psychological robustness? *J Dent* 2010;38:232—6.
8. Hama Y, Kanazawa M, Minakuchi S, Uchida T, Sasaki Y. Properties of a color-changeable chewing gum used to evaluate masticatory performance. *J Prosthodont Res* 2014;58:102—6.
9. Shiga H, Ishikawa A, Nakajima K, Tanaka A. Relationship between masticatory performance using a gummy jelly and food intake ability in Japanese complete denture wearers. *Odontology* 2015;103:356—9.
10. Limpuangthip N, Somkotra T, Arksornnukit M. Subjective and objective measures for evaluating masticatory ability and associating factors of complete denture wearers: a clinical study. *J Prosthet Dent* 2021;125:287—93.
11. Takagi D, Watanabe Y, Edahiro A, et al. Factors affecting masticatory function of community-dwelling older people: investigation of the differences in the relevant factors for subjective and objective assessment. *Gerodontology* 2017;34:357—64.
12. Pedroni-Pereira A, Marquezin MCS, Araujo DS, Pereira LJ, Bommarito S, Castelo PM. Lack of agreement between objective and subjective measures in the evaluation of masticatory function: a preliminary study. *Physiol Behav* 2018;184:220—5.
13. Krejcie RV, Morgan DW. Determining sample size for research activities. *Educ Psychol Meas* 1970;30:607—10.
14. Adam AM. Sample size determination in survey research. *J Sci Res Rep* 2020;26:90—7.
15. Liu HY, Chen JH, Hsu KJ, et al. Decreased tongue pressure associated with aging, Chewing and swallowing difficulties of community-dwelling older adults in Taiwan. *J Personalized Med* 2021;11:653.
16. World Health Organization. *Oral health surveys: basic methods*, 5th ed. Geneva, Switzerland: World Health Organization, 2013.
17. Eichner K. Renewed examination of the group classification of partially edentulous arches by Eichner and application advices for studies on morbidity statistics. *Stomatol DDR* 1990;40: 321—5.
18. Ikebe K, Matsuda K, Murai S, Maeda Y, Nokubi T. Validation of the Eichner index in relation to occlusal force and masticatory performance. *Int J Prosthodont (IJP)* 2010;23:521—4.
19. Kosaka T, Ono T, Kida M, et al. A multifactorial model of masticatory performance: the Suita study. *J Oral Rehabil* 2016; 43:340—7.
20. Igarashi K, Watanabe Y, Kugimiya Y, et al. Validity of a visual scoring method using gummy jelly for evaluating chewing efficiency in a large-scale epidemiological survey. *J Oral Rehabil* 2019;46:409—16.
21. Sagawa K, Furuya H, Ohara Y, et al. Tongue function is important for masticatory performance in the healthy elderly: a cross-sectional survey of community-dwelling elderly. *J Prosthodont Res* 2019;63:31—4.
22. Ohno K, Fujita Y, Ohno Y, Takeshima T, Maki K. The factors related to decreases in masticatory performance and masticatory function until swallowing using gummy jelly in subjects aged 20-79 years. *J Oral Rehabil* 2020;47:851—61.
23. Ikebe K, Matsuda K, Kagawa R, et al. Association of masticatory performance with age, gender, number of teeth, occlusal force and salivary flow in Japanese older adults: is ageing a risk factor for masticatory dysfunction? *Arch Oral Biol* 2011;56:991—6.
24. Iwasaki M, Yoshihara A, Sato N, et al. A 5-year longitudinal study of association of maximum bite force with development of frailty in community-dwelling older adults. *J Oral Rehabil* 2018;45:17—24.
25. Chen HH, Lin PY, Lin CK, Lin PY, Chi LY. Effects of oral exercise on tongue pressure in Taiwanese older adults in community day care centers. *J Dent Sci* 2022;17:338—44.
26. Kugimiya Y, Iwasaki M, Ohara Y, et al. Relationship between oral hypofunction and sarcopenia in community-dwelling older adults: the Otassha study. *Int J Environ Res Publ Health* 2021; 18:6666.
27. Nakatsuka Y, Yamashita S, Nimura H, Mizoue S, Tsuchiya S, Hashii K. Location of main occluding areas and masticatory ability in patients with reduced occlusal support. *Aust Dent J* 2010;55:45—50.