COMMUNICATION SCIENCES & DISORDERS

Original Article

| ISSN 2288-0917 (Online) | Commun Sci Disord 2025;30(1):136-146

https://doi.org/10.12963/csd.250094

Relationships among Speech Intelligibility, Chewing Ability and Depression in Older Adults

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Received: January 3, 2025
Revised: February 26, 2025
Accepted: March 20, 2025

Objectives: Due to anatomical and physiological changes, older adults often experience impaired speech intelligibility and reduced chewing ability which are frequently accompanied by depression. However, little research has been conducted to demonstrate the relationships between these measures. The aim of this study was to identify the overall relationships among speech intelligibility, chewing ability, and depression in accordance with orofacial functions in the elderly. **Methods:** Twenty-one healthy older adults (10 males; 11 females) participated in this study. The functions of lip, cheek, tongue, and soft palate, as well as chewing ability including regularity, frequency, duration and velocity measures, speech intelligibility and depression by Geriatric Depression Scale-Short Form were measured. **Results:** Most participants had normal orofacial functions, speech intelligibility, chewing ability and no signs of depression. Tongue strength was significantly correlated with range and velocity of the tongue movement and puffed cheek. Lip closure was not significantly related to other orofacial functions. The puffed cheek was significantly correlated with age. Speech intelligibility and chewing regularity had similar relationships and regression analysis results with orofacial functions. The velocity of the tongue movement was the only measure that correlated with and explained depression. **Conclusion:** Because speech and chewing share similar anatomical structures and overlapping neurophysiology, speech intelligibility and chewing had similar relationships with orofacial functions. Reduced speech and chewing ability can limit social activity and participation, which may eventually cause depression in older adults. Further research is necessary to explore the relationships between various variables affected by aging to better understand the older population.

Keywords: Aging, Speech intelligibility, Chewing, Depression, Relationship

Statistics Korea reported that the older population aged 65 years and older accounts for approximately 19.2% of the total population in Korea as of 2024 (Statistics Korea, 2024). It is projected that Korea will enter a 'super-aged society' in 2025 (Statistics Korea, 2024). Aging is inevitable and irreversible across the individual lifespan (Dziechciaż & Filip, 2014) and understanding the characteristics of aging is crucial as we prepare for the upcoming 'super-aged society'.

The World Health Organization (2001) provides the International Classification of Functioning, Disability and Health classifying individual functioning into 1) body functions and structures, and 2) activities and participation. Aging causes a gradual decline of structures and functions including loss of bone density, reduced number of cells, reduced muscle and skeletal mass, increased fibrosis, reduced pulmonary function, reduced cognitive and memory function, loss of high-frequency hearing, and reduced smell (Dziechciaż & Filip, 2014; Harada, Natelson Love, & Triebel, 2013; Power, Dalton, & Rice, 2013; Steinberg et al., 2013; Toogood, 2003). These anatomical and physiological changes, combined with environmental factors which are extrinsic aspects to individuals and

bring about a reaction from them, lead to restrictions of social activity and participation (de Mendonça Lima & Ivbijaro, 2013; Ohrnberger, Fichera, & Sutton, 2017). Consequently, older adults may experience social isolation and loneliness. If these feelings persist, they can suffer from mental illness such as depression and anxiety disorders (Adolfo, Albougami, Roque, Aruta, & Almazan, 2022; Campagne, 2019; Dziechciaż & Filip, 2014; Lakatta, Mitchell, Pomerance, & Rowe, 1987; Teo, Cheng, Cheng, Lau, & Lau, 2023).

Speech production and chewing are highly complex sensorimotor behaviors that require simultaneous coordination with multiple structures, muscles and neural networks (Madhavan, Lam, Etter, & Wilkinson, 2023; Segawa, Tourville, Beal, & Guenther, 2015). Speech production involves motor planning and respiratory control, phonation, articulation, and resonance engaging various structures such as lungs, diaphragm, larynx, pharynx, vocal folds, tongue, lips, soft palate, teeth, jaw and nasal cavity (Scott, Wyleziska, Birch, & Miquel, 2014; Shen & Sie, 2014; Weismer, Yunusova, & Bunton, 2012). In addition, feedforward commands and feedback control play critical roles in speech motor control (Perkell, 2012). Speech intelligibility is defined as the degree to which a listener can correctly identify and understand spoken speech (Coppens-Hofman, Terband, Snik, & Maassen, 2016). Achieving optimal speech intelligibility relies on the effective coordination of speech mechanisms. Reduced speech intelligibility causes misunderstanding, frustration, and loss of interest by communication partners (Coppens-Hofman et al., 2016; Hustad, 2012).

Chewing or mastication is to reduce food effectively and rapidly (Wall & Smith, 2001). The chewing process requires movements of the structures including tongue, jaw, cheek, teeth, soft palate, and hyoid bone, and masticatory muscles to place and process the food (Matsuo & Palmer, 2008). Sensory input from the bolus characteristics can modify the amount and trajectories of these movements, while continuous sensory feedback during the chewing process adjusts motor output (Gaszynska, Godala, Szatko, & Gaszynski, 2014; van der Bilt & Abbink, 2017). Impairments of chewing for bolus manipulation cause swallowing dysfunctions in both oral and pharyngeal phases, leading to malnutrition, poor eating quality, and reduced quality of life (Baba, John, Inukai, Aridome, & Igarahsi, 2009; Medeiros et al., 2024).

Due to anatomical and physiological changes in older adults, it is reasonable to expect impaired speech intelligibility and chewing ability in this population. Several studies have described changes of speech production (Arslan & Göksun, 2022; Gollan & Goldrick, 2019; Tucker, Ford, & Hedges, 2021) and chewing difficulties (Abreu et al., 2023; Locker, 2002; Woo, Tong, & Yu, 2018). However, although speech production and chewing function share many orofacial structures and functions, and physiological changes are eventually related to psychological aspects such as depression, research on the relationships among speech outcome, chewing ability, and depression in older adults remains limited. Albuquerque et al. (2021) demonstrated that adults with depression presented higher vowel duration, longer total pause duration and shorter total speech duration and older adults were more likely to have depression compared to younger adults. Similarly, Mijnders, Janse, Naarding, and Truong (2023) identified that older adults with depression showed slower speech rate and longer mean pause duration compared to those without depression. In addition, Laudisio et al. (2014) and Chun and Doo (2021) determined that chewing problems are significantly associated with depression in the elderly. Cho and Kim (2019) demonstrated that chewing ability was more likely to cause pain, discomfort, anxiety, and depression in older adults. Despite these findings, little research has been conducted to investigate the relationships among speech intelligibility, chewing capability and depression in older adults.

Thus, this study aimed to identify the overall relationships among speech intelligibility, chewing ability, and depression in the elderly. The specific aims of this study were as follows: 1) To understand the characteristics of orofacial functions, speech intelligibility, chewing and depression in older adults; 2) To identify the relationships between variables, including age, sex, orofacial functions, speech intelligibility, chewing and depression; and 3) To describe the impact of orofacial functions on speech intelligibility, chewing, and depression.

METHODS

Participants

The Severance Hospital Institutional Review Board (IRB No. 4-2018-0113, 4-2019-1138) approved the study procedures, and all participants provided verbal and written informed consent. Twen-

Table 1. Participant characteristics

Variables	N	%
Sex		
Male	10	47.6
Female	11	52.4
Age (yr)		
Mean ± SD (range)	75.38 ± 5.98 (67-91)	
65-74	10	47.6
75-84	9	42.9
85-94	2	9.5
Education (yr)		
Mean ± SD (range)	12.67 ± 4.78 (5-18)	
≤ Elementary school	6	28.6
Middle school	1	4.8
High school	1	4.8
≥ University	13	61.9
K-MMSE		
Mean ± SD (range)	27.76 ± 1.38 (25-30)	

K-MMSE = Korean mini-mental state examination (Kang, 2006).

ty-one healthy older adults (10 males; 11 females) with an average age of 75.38 ± 5.98 years (mean ± SD; range: 67-91 years) participated in this study from May 2018 to November 2020 at five senior community centers (Table 1). Individuals aged 65 years old or older with no self-reported history of the following conditions were eligible for participation: 1) neurological disease, 2) head and neck cancer, 3) breathing disorders or diseases, and 4) speech, language, and swallowing disorders. Participants were also required: 1) not to reside in a hospital or nursing facility; 2) to have normal communication skills (e.g., speaking, listening, reading, writing); 3) to have at least 20 teeth; and 4) to demonstrate normal cognitive function.

Self-reported demographic information was collected, including age, sex, medical history, years of education, denture status, and number of teeth lost. Because at least 20 teeth are required for normal Korean meals (Lee, 2024), we excluded participants who have less than 20 teeth or do not have dentures. In addition, only individuals who had normal cognitive function measured by Korean mini-mental status examination (Kang, 2006) participated in this study. The participant characteristics were summarized in Table 1.

Evaluation of Outcome Measures

Two speech-language clinicians who were certified Korean Speech-Language Pathologists conducted evaluations. These outcome measures of each participant were assessed independently; however, any difficult or questionable evaluations were discussed during the evaluation process. Agreements between the two evaluators, when comparing the results of orofacial functions, chewing ability, and speech intelligibility in seven participants who had been evaluated by both, were 92%, 94%, and 93%, respectively.

Orofacial Functions

Participants were seated in an upright position throughout the evaluations. Six outcome measures were rated on a 5-point Likert scale from 0 (*normal*) to 4 (*profoundly impaired*): 1) Lip closure; 2) Puffed cheek; 3) Tongue strength, with an instruction that "Push your tongue against the tongue depressor."; 4-5) Range and velocity of the tongue movement as participants moved their tongue tip from left to right side of the mouth; and 6) Soft palate movement during phonation of vowel /a/ sound. The six orofacial functions were selected based on their potential to impact both chewing and speech functions.

Chewing

The participants were instructed to chew on a slice of a cracker (IVY™, Haitai Inc.; 4.6 × 4.6 cm, 3.29 g). The number of chewing (frequency) and duration of chewing (seconds) required to complete chewing were manually measured based on the jaw movement using a timer. The rate of normal chewing was then calculated as frequency divided by duration. In addition, the regularity of the jaw movement was rated using a 5-point Likert scale ranging from 0 (*normal*) to 4 (*profoundly impaired*).

Speech Intelligibility

We measured speech intelligibility as a speech outcome to assess overall speech ability in older adults. We evaluated speech intelligibility with natural speech throughout the entire evaluation process. It was scored on a 5-point Likert scale (0: *normal*, 5: *profoundly impaired*).

Depression

Although studies on the relationship between depression and chewing as well as between depression and speech ability exist, lit-

https://doi.org/10.12963/csd.250094

tle research has investigated the relationship among depression, chewing and speech abilities. Therefore, depression was measured to explore the relationship among these three variables. To screen for depression, we used Geriatric Depression Scale-Short Form (GDS-SF) (Jang et al., 2001), a self-rated questionnaire to identify a risk of/with depression in older adults. GDS-SF includes 15 yes-no questions, with a total score of 15. Scores below 6 are considered normal, while scores of 6 or higher indicate a risk of depression.

Data Analysis

Data was analyzed using SPSS Statistics 25 (IBM Corp., Armonk, NY, USA). Descriptive statistics were used to analyze the demographic information of the participants and understand the characteristics of orofacial functions, speech intelligibility, chewing, and depression of them. To analyze the relationships between variables including age, orofacial functions, speech intelligibility, chewing and depression, we performed Pearson's correlation analysis. The relationship between sex and other variables was analyzed with Spearman's Rho correlation analysis.

Additionally, stepwise multiple regression was conducted to identify the impact of orofacial functions on speech intelligibility, chewing and depression: The dependent variables included speech intelligibility, chewing abilities (frequency, duration, velocity, and regularity) and depression, while the independent variables were all six orofacial functions. Because the Likert scale responses exhibited a linear relationship as indicated by Pearson's correlation coefficient, and the similarity between Pearson's and Spearman's correlation coefficients suggested a consistent monotonic relationship, we treated the Likert scale responses as continuous variables in our analysis.

RESULTS

Characteristics of Orofacial Functions, Speech Intelligibility, Chewing and Depression

Most participants had normal orofacial functions, speech intelligibility, and chewing regularity, while a small number of participants had mildly impaired these measures. Table 2 provided detailed characteristics of these outcome measures. There were two missing data for chewing regularity, but duration, frequency, and velocity of the tongue movement were measured for all participants. The average chewing duration, frequency, and velocity were 47.00 ± 13.58 seconds (range: 29-71 seconds), 63.95 ± 27.03 (range: 33-152), 1.36 ± 0.35 (range: 0.76-2.14), respectively. GDS-SF score was 3.48 ± 2.62 (Mean ± SD) with a range of 1-12, and two individuals exhibited depressive symptoms.

Table 2. Descriptive characteristics of orofacial function, speech intelligibility, chewing, and depression of the participants

Variables	N	%
Orofacial function		
Tongue strength		
Normal	19	90.5
Mild (sex, age group (N))	2 (females; 65-74 (1), 85-94 (1))	9.5
Tongue range		
Normal	18	85.7
Mild (sex, age group (N))	3 (females, 65-74 (2), 85-94 (1))	14.3
Tongue velocity		
Normal	19	90.5
Mild (sex, age group (N))	2 (females, 65-74 (1), 75-84 (1))	9.5
Puffed cheek		
Normal	19	90.5
Mild (Sex, Age group (N))	2 (male, 75-84 (1); female, 85-94 (1))	9.5
Lip closure		
Normal	18	85.7
Mild (sex, age group (N))	3 (male, 75-84 (2); female, 65-74 (1))	14.3
Soft palate movement		
Normal	21	100
Speech		
Speech intelligibility		
Normal	20	95.2
Mild (sex, age group)	1 (female, 65-74)	4.8
Chewing		
Chewing regularity		
Normal	18	94.7
Mild (sex, age group (N))	1 (female, 65-74)	5.3
Chewing duration (seconds)		
Mean ± SD (range)	47.00 ± 13.58 (29-71)	
Chewing frequency		
Mean ± SD (range)	63.95 ± 27.03 (33-152)	
Chewing velocity		
Mean ± SD (range)	1.36 ± 0.35 (0.76-2.14)	
Depression		
GDS-SF		
Mean ± SD (range)	3.48 ± 2.62 (1-12)	

GDS-SF = Geriatric depression scale-short form (Jang et al., 2001).

Table 3. Correlations between age, sex, orofacial function, speech intelligibility, chewing and depression

	Age	Sex	Tongue strength	Tongue range	Tongue velocity	Puffed cheek	Lip closure	Speech intelligibility	Chewing regularity	Chewing duration	Chewing frequency	Chewing velocity	Depression
Age	1	-.264	.189	.030	-.059	.438*	.030	-.212	-.202	.358	.298	.118	-.091
Sex***		1	.309	.389	.309	-.015	-.156	.213	.201	.347	.205	-.126	.115
Tongue strength			1	.795**	.447*	.447*	.331	.689**	.687**	.355	.019	-.283	-.124
Tongue range				1	.331	.331	.222	.548*	.544*	.226	.109	.040	-.129
Tongue velocity					1	-.105	.331	.689**	.687**	.367	.130	-.169	.447*
Puffed cheek						1	.331	-.073	-.081	.196	-.061	-.278	-.060
Lip closure							1	.548*	.544*	.021	-.237	-.404	-.129
Speech intelligibility								1	1.000**	.101	-.076	-.211	-.129
Chewing regularity									1	.098	-.087	-.217	-.153
Chewing duration										1	.741**	.029	.250
Chewing frequency											1	.669**	.211
Chewing velocity												1	.042
Depression													1

*$p<.05$, **$p<.01$.
***The relationship between sex and other variables was analyzed with Spearman's Rho correlation analysis while other relationships between variables were performed using Pearson's correlation analysis.

Relationships between Variables Including Age, Sex, Orofacial Functions, Speech Intelligibility, Chewing and Depression

Soft palate movement was statistically excluded as a variable on the process of SPSS analysis as all participants had normal soft palate function (constant). Age was positively correlated with puffed cheek ($p<.05$). Orofacial functions were significantly correlated with other variables as follows: 1) Tongue strength was positively correlated with range of ($p<.01$), and velocity of the tongue movement ($p<.05$), puffed cheek ($p<.05$), speech intelligibility ($p<.01$), and chewing regularity ($p<.01$); 2) Range of the tongue movement was positively correlated with speech intelligibility ($p<.05$) and chewing regularity ($p<.05$); 3) Velocity of the tongue movement was positively correlated with speech intelligibility ($p<.01$), chewing regularity ($p<.01$) and depression ($p<.05$); and 4) Lip closure was positively correlated with speech intelligibility ($p<.05$) and chewing regularity ($p<.05$). Speech intelligibility was positively correlated with chewing regularity ($p<.01$). Chewing duration was positively correlated with chewing frequency ($p<.01$), and chewing frequency was positively correlated with chewing velocity ($p<.01$). Correlations between outcome measures were shown in Table 3.

Impact of Orofacial Functions on Chewing, Speech Intelligibility and Depression

All variance inflation factors (VIFs) from the stepwise regression analysis were less than two, and there was no multicollinearity. Speech intelligibility was significantly predicted by: 1) tongue strength (Model 1) demonstrating an explanatory power of about 47.5% ($F=17.190$, $p<.01$); 2) tongue strength and velocity of the tongue movement (Model 2) indicating an explanatory power of about 65.6% ($F=17.190$, $p<.01$); 3) tongue strength, velocity of the tongue movement and puffed cheek (Model 3) demonstrating an explanatory power of about 73.7% ($F=15.921$, $p<.01$); 4) tongue strength, velocity of the tongue movement, puffed cheek and lip closure (Model 4) demonstrating an explanatory power of about 87.3% ($F=27.429$, $p<.001$); and 5) tongue strength, puffed cheek and lip closure (Model 5) indicating an explanatory power of about 85.1% ($F=32.429$, $p<.001$). Chewing regularity was significantly affected by 1) tongue strength (Model 1) demonstrating an explanatory power of about 47.2% ($F=15.211$, $p<.01$), 2) tongue strength and puffed cheek (Model 2) indicating an explanatory power of about 65.5% ($F=15.211$, $p<.001$), and 3) tongue strength, puffed cheek and lip closure (Model 3) demonstrating an explanatory power of about 85.1% ($F=28.474$, $p<.001$). There were no significant predictors for other chewing outcomes including chewing

https://doi.org/10.12963/csd.250094

Table 4. Stepwise multiple regression analysis

Dependent variable	Model	Independent variable	B	SE	β	*t*	R^2	adjusted R^2
Speech intelligibility	Step 1	Tongue strength	.500	.121	.689	4.146**	.475	.447
	Step 2	Tongue strength	.345	.112	.476	3.082**	.656	.618
		Tongue velocity	.345	.112	.476	3.082**		
	Step 3	Tongue strength	.500	.121	.689	4.123**	.737	.691
		Tongue velocity	.250	.109	.345	2.292*		
		Puffed cheek	-.250	.109	-.345	-2.292*		
	Step 4	Tongue strength	.500	.087	.689	5.745***	.873	.841
		Tongue velocity	.136	.083	.188	1.643***		
		Puffed cheek	-.364	.083	-.501	-4.382		
		Lip closure	.258	.062	.423	4.123**		
	Step 5	Tongue strength	.575	.078	.793	7.398***	.851	.825
		Puffed cheek	-.425	.078	-.586	-5.468***		
		Lip closure	.292	.062	.479	4.719***		
Chewing regularity	Step 1	Tongue strength	.500	.128	.687	3.900**	.472	.441
	Step 2	Tongue strength	.653	.119	.898	5.488***	.655	.612
		Puffed cheek	-.347	.119	-.477	-2.915*		
	Step 3	Tongue strength	.575	.083	.791	6.952***	.851	.821
		Puffed cheek	-.425	.083	-.583	-5.128***		
		Lip closure	.292	.066	.478	4.429***		
Depression	Step 1	Tongue velocity	3.895	1.787	.447	2.179*	.200	.158

*p < .05, **p < .01, ***p < .001.

duration, frequency and velocity. Depression was significantly influenced by the velocity of the tongue movement indicating an explanatory power of about 20.0% (F = 4.750, p < .05) (Table 4).

DISCUSSION

To our knowledge, this was the first study to identify the relationships among speech intelligibility, chewing ability and depression in accordance with orofacial functions in older adults. The orofacial functions of the participants in this study were generally normal (over 85% of the participants of each criterion), and speech intelligibility and chewing regularity of those were also normal, except for one individual in both measures. Compared to the previous study on chewing in Korean normal older adults with similar average age (Kim, Lee, You, & Kim, 2022), the descriptive characteristics of chewing, including chewing duration, frequency, and velocity in this study were similar. In addition, while the average score of depression by GDS-SF showed normal, two individuals exhibited depressive symptoms.

We collected data from senior community centers, where elderly people can access resources from various areas, remain socially engaged, and stay connected to their community (Kang, 2012; Kim & Jin, 2023). The generally normal functions observed in this study may be attributed to the source of data collection. Elderly community centers offer lifelong learning and recreational programs, enabling older adults to pursue personal growth, socialization and friendships. Participating in these programs often include eating, talking, and engaging with peers, providing opportunities for physical activity and emotional support. Consequently, older adults who voluntarily participated in this study were likely to be functional individuals with fewer physical limitations and greater emotional well-being.

The orofacial functions in aging have been documented with a focus on the strength of orofacial structures (Clark & Solomon, 2012; Park, You, Kim, Yeo, & Lee, 2015; Robbins et al., 2005; Robbins, Levine, Wood, Roecker, & Luschei, 1995). Studies measuring tongue protrusion and lateralization strength, as well as cheek and lip compression, found that tongue strength in older adults is reduced compared to younger adults (Clark & Solomon, 2012; Park et al., 2015; Robbins et al., 1995). However, other measures except tongue strength did not significantly differentiate older adults from younger adults (Clark & Solomon, 2012; Park et al., 2015; Robbins

et al., 1995). It suggested that facial muscles, particularly those involved in lip and cheek functions, may be less vulnerable to aging.

This study identified that tongue strength was significantly correlated with other tongue measures, including range and velocity of the tongue movement and puffed cheek in older adults. Lip closure, however, was not significantly related to other orofacial functions. Interestingly, puffed cheek was significantly correlated with age, contrasting with the findings of previous studies. This discrepancy may be attributed to the fact that the current study compared puffed cheek measures within the elderly group, rather than between older and younger groups. Future research examining orofacial functions across elderly groups is necessary to confirm this hypothesis.

In addition, previous studies reported inconsistent results regarding sex differences in tongue, lip and cheek strength measures across young, middle-aged and older groups (Clark & Solomon, 2012; Park et al., 2015). For example, some studies found significantly greater lip and cheek strength in men (Clark & Solomon, 2012), while others observed significantly greater strength in all lip, cheek, and tongue measures in men (Park et al., 2015). In this study, no significant sex differences were observed in tongue, cheek, or lip measures. This lack of difference may also result from the comparison made within the elderly group, highlighting the need for further studies to confirm the sex effects on orofacial functions across in older age groups.

Speech intelligibility was significantly related to all tongue measures, lip closure, and chewing regularity. It was also significantly explained by tongue strength, velocity of the tongue movement, puffed cheek and lip closure. Similarly, chewing regularity was significantly related to all tongue measures, lip closure, and speech intelligibility, and all tongue measures, puffed cheek, and lip closure significantly predicted chewing regularity. These findings suggested that speech intelligibility and chewing regularity share similar relationships with orofacial functions, as well as similar regression results. This similarity may be due to shared anatomical structures and overlapping neurophysiological mechanisms between speech and chewing (Eickhoff, Heim, Zilles, & Amunts, 2009; Malandraki, Johnson, & Robbins, 2011): 1) Tongue, lip, and cheek which are articulators for speech play major roles in producing speech sounds such as vowel, bilabial consonant, and velar consonant (Movérare, Lohmander, Hultcrantz, & Sjögreen, 2017); 2) Articulation influences speech intelligibility to make the listener understand what the speaker says and maintain the conversation; and 3) These same articulators are involved in the oral phase of swallowing such as bolus containment without drooling, chewing, and bolus management (Movérare et al., 2017). Additionally, the maximum velocity of the tongue movement has been identified as a significant contributor to speech intelligibility (Kuruvilla-Dugdale, Dietrich, McKinley, & Deroche, 2020), while reduced chewing ability in older individuals has been associated with the velocity of the tongue movement and/or tongue strength (Sagawa et al., 2019). The results of this study align with these previous findings, further emphasizing the interconnected roles of orofacial functions in speech and chewing in older adults.

Interestingly, the velocity of the tongue movement was the only measure that correlated with and explained depression. The tongue helps position the bolus on the occlusal surface of the teeth for chewing, facilitating the preparation for bolus transport (Hiiemae & Palmer, 2003). When the velocity of the tongue movement decreases, it takes more time to chew the bolus and restricts the variety of food that can be eaten, ultimately leading to malnutrition (Matsuo & Palmer, 2008). Similarly, a reduced velocity of the tongue movement can result in longer vowel and total pause durations, as well as a slower speech rate, all of which have been linked to depression (Albuquerque et al., 2021; Mijnders et al., 2023). Reduced speech and chewing ability can limit social activity and participation, which may eventually lead to psychological issues. Therefore, the relationship between velocity of the tongue movement and depression can be understood within this context. This insight emphasizes the importance of assessing tongue movement not only for its impact on physical abilities but also for its potential connection to mental health. Understanding the relationship between velocity of the tongue movement and depression could help identify individuals at risk for psychological issues through tongue movement.

Despite providing valuable insights into the relationships among speech intelligibility, chewing ability, and depression according to orofacial functions, this study has some limitations. First, more representative results may be obtained by collecting data from a wider range of locations beyond community centers. Second, chewing ability was manually measured based on the jaw move-

https://doi.org/10.12963/csd.250094

ments. Incorporating objective measurement tools such as surface electromyography (sEMG) could provide more precise assessments of jaw movements and its impact on chewing function. Third, we acknowledge the concern regarding statistical power given the small sample size (N = 21) and multiple independent variables in the regression model. To mitigate this, we carefully selected variables to avoid overfitting and conducted checks for multicollinearity. Additionally, we interpreted the results with caution, reporting effect sizes alongside *p*-values (Table 4). Lastly, given the limited number of participants, it may be cautious to generalize the findings regarding the relationships between outcome measures before further research, including more participants and more detailed assessment tools to observe specific characteristics of the measures, is conducted.

CONCLUSION

This study identified the overall relationships among speech intelligibility, chewing ability, and depression in accordance with orofacial functions in the elderly. Physiological changes associated with aging restrict speech and chewing abilities, leading to limited social activities and emotional distress. It may be cautious to generalize the results due to the screening nature of the assessment tools and small number of participants. However, the significance of this study lies in its ability to provide an overview of the relationships among the three variables and to lay the groundwork for future research. Further study is necessary to explore the relationships between various aging-related variables such as the relationship among respiratory function, speech, swallowing or chewing and different psychological problems (e.g., isolation) to better understand the older population.

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국문초록

정상 노인의 말 명료도, 씹기 능력, 우울증 간의 관계

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배경 및 목적: 노인들은 해부학적, 생리학적 변화로 인해 말 명료도와 씹기 능력의 저하를 경험하고 이는 종종 우울증을 동반한다. 그러나 이러한 측정치들 간의 관계는 거의 연구되지 않았다. 이에 본 연구에서는 노인의 구강안면 기능에 따른 말 명료도, 씹기 능력 및 우울증 간의 전반적인 관계를 살펴보고자 한다. 방법: 평균 연령이 75.38 ± 5.98세(평균 ± SD)인 건강한 노인 21명(남: 10명; 여: 11명)이 본 연구에 참여하였다. 입술, 뺨, 혀, 연구개의 기능 및 씹기 능력(씹기의 규칙성, 빈도, 지속 시간 및 속도)과 말 명료도, Geriatric depression scale-short form을 통한 우울증 여부를 측정하였다. 결과: 대부분의 참가자는 정상적인 구강안면 기능, 말 명료도, 씹기 능력을 보였고 우울증 징후도 보이지 않았다. 혀의 힘은 혀 움직임의 범위와 속도 및 볼 부풀리기 기능과 유의한 상관관계가 있었지만, 입술 다물기는 다른 구강안면 기능과 유의한 상관관계가 없었다. 볼 부풀리기 기능은 나이와 유의한 상관관계가 있었다. 말 명료도와 씹기의 규칙성은 구강안면 기능과의 유사한 상관관계 및 회귀분석 결과를 나타냈다. 혀 움직임의 속도는 우울증과 유일한 상관관계를 보였고, 우울증을 설명하는 유일한 척도였다. 논의 및 결론: 말과 씹기는 유사한 해부학적 구조 및 신경학적 생리를 공유하기 때문에 말 명료도와 씹기 능력은 구강안면 기능과의 상관관계가 유사하였다. 노인의 말과 씹기 능력의 저하는 사회적 활동과 참여를 제한하여 결국 우울증으로 이어질 수 있다. 향후에는 노인들을 더 잘 이해하기 위해 노화의 영향을 받는 다양한 변수들 간의 관계에 대한 연구가 필요할 것이다.

핵심어: 노화, 말 명료도, 씹기, 우울증, 상관관계

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https://doi.org/10.12963/csd.250094