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Determination of the Relationship between Voice and Swallowing Characteristics in Individuals Aged 65 and Over with Sarcopenia Risk

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ABSTRACT

Objective: Sarcopenia, which increases with age, causes a decrease in muscle mass and strength, potentially leading to changes in the voice's acoustic, perceptual, and aerodynamic parameters, as well as dysphagia. This study aimed to assess the voice and swallowing functions of individuals aged 65 years at risk of sarcopenia and to explore the relationship between these functions.
Method: Forty-nine participants who scored ≥4 on the Sarcopenia Risk Assessment Scale were included. Acoustic analysis was performed using the Multi-Dimensional Voice Programme (MDVP), and aerodynamic analysis included the maximum phonation time (MPT) and the s/z ratio. Swallowing was evaluated using the Swallowing Function Screening Test (EAT-10).
Results: Participants were categorised into dysphagic (n=29) and non-dysphagic (n=20) groups based on their EAT-10 scores. Significant differences were found in several acoustic parameters, including fundamental frequency (F0), Shimmer, vAm, and FTRI (p=0.011, p=0.043, p=0.037, p=0.001). A significant difference in the SPI parameter was observed only in female participants (p=0.028). MPT showed significant differences between the dysphagic and non-dysphagic groups in both men and women (p=0.001, p=0.003, p=0.037). Positive correlations were found between EAT-10 and the acoustic parameters SPI and FTRI (p=0.031, p=0.048), while a negative correlation was found between MPT and EAT-10 (p=0.001).
Conclusion: MPT was decreased in dysphagic individuals aged ≥65 years at risk of sarcopenia, and parameters related to decreased respiratory support and control, vocal cord closure, and airflow control during vocal cord adduction were negatively affected. These findings suggest that these parameters may be related to dysphagia risk factors in elderly individuals at risk of sarcopenia.
Keywords: Voice, swallowing, dysphagia, sarcopenia, voice analysis

INTRODUCTION

Recent studies on the human lifespan have shown that the number of elderly people is increasing worldwide and birth rates are decreasing (1). From a medical point of view, old age is a period in the life course in which losses and declines are frequently observed. The population group defined as "the older adults" constitutes a special segment that carries more health risks and has specific problems compared with other age groups (2). With ageing, the incidence of chronic diseases and cancers increases, cognitive abilities decrease, and skipping meals or malnutrition is common (35-40%) due to psychological and care problems. These conditions may lead to malnutrition and many health problems (3).

One of the important changes that occur in the ageing process is sarcopenia. "Sarcopenia is defined as a decrease in muscle mass and strength during the ageing process, and this is commonly observed in elderly individuals" (4). Sarcopenia induces functional and structural declines in muscles, leading to decreased mobility, falls, and increased fragility (1). The incidence of sarcopenia increases with age (1). Research shows that the prevalence of sarcopenia ranges from 5 to 25% in individuals aged 60-70 years and from 11 to 50% in those. Sarcopenia is linked to physical limitations, dependence on others, increased risk of falls, respiratory and immune system issues, reduced quality of life, and mortality (3).

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Sarcopenia is categorised as either primary or secondary based on its causes (5). Primary sarcopenia is mainly caused by ageing, while secondary sarcopenia is associated with factors like physical inactivity, malnutrition, and conditions such as stroke and Alzheimer's disease (6). Moreover, sarcopenia is linked to various adverse health outcomes, including disability, increased mortality, a higher risk of falls, longer hospital stays, and a greater need for post-discharge (7). Recent studies have also suggested a link between sarcopenia and dysphagia given that the overall decline in muscle mass and strength in the elderly might affect the muscles involved in swallowing (6).

Hoarseness and dysphagia can occur simultaneously, but the relationship between these symptoms in individuals with sarcopenic dysphagia is not well understood. Consequently, sarcopenia can cause both voice and swallowing difficulties. The primary cause of hoarseness is the irregular vibration of the vocal cords. This irregularity can be attributed to the insufficient functioning of the thyroarytenoid, arytaenoid, and lateral cricoarytenoid muscles, which are involved in vocal cord vibration. These muscles help close the vocal cords, contribute to voice production, and prevent aspiration. Therefore, impaired muscle function may result in both hoarseness and difficulty in swallowing voice (8).

The anatomical and physiological changes that occur with ageing affect the acoustic, perceptual, and aerodynamic parameters of the voice. The reduction in respiratory support results from age-related alterations in the respiratory system and oral motor structure, decreased secretion, loss of muscle mass, and muscle atrophy. In addition, changes in social and employment status, losses experienced, perceived physical changes, and psychological conditions during old age may also have positive or negative effects on voice (9). In individuals aged 60 years, atrophic changes in the laryngeal muscles responsible for voice production can result in long-term weakening of the voice and alterations in vocal quality. This condition can be manifested by symptoms such as roughness and breathiness, pitch changes, decreased vocal intensity, tremors, decreased speech rate, and vocal fatigue. The inability to project the voice in noisy environments can reduce communication effectiveness and lead to social anxiety. This can negatively affect the quality of life and cause psychological problems. Therefore, appropriate interventions should be provided to patients with presbyphonia (10).

Presbyphonia is a vocal condition caused by the ageing process and impacts 12-35% of the elderly (11, 12). After 65 years of age, ageing leads to structural, functional, and physiological changes in the larynx (11, 12). The key symptoms of presbyphonia include hoarseness, a weak and low voice, trouble producing high-pitched sounds, difficulty singing, breathlessness, and voice strain (11-14). Videolaryngoscopic examination revealed prominent changes such as marked concavity of the vocal folds, prominence of the vocal apophyses, pseudo-sulcus vocalis, bowing vocal folds, and glottic insufficiency. These symptoms and observations reflect the effects of ageing on the vocal system (11, 15, 16).

Structural and functional changes in the aging presbylarynx include hyaline cartilage calcification, decreased glandular secretion, reduced neuromotor transmission, atrophy of the thyroarytenoid muscle (vocal muscle), thinning of the vocal fold epithelium, increase in the extracellular fibrous matrix (with more collagen fibers and fewer elastic fibers), and reduction in hyaluronic acid levels. Additionally, ageing may lead to reduced lung capacity and less precise articulation because of tooth loss, slower speech rate, and decreased saliva production. These changes can indirectly affect the vocal output and speech quality (17).

To identify voice problems and apply appropriate treatment protocols, a detailed evaluation of the individual's voice is necessary. In this comprehensive evaluation process, both instrumental and perceptual evaluations were performed. Instrumental evaluation provides anatomical examination of the vocal cord structures and observation of the movements of these structures. Aerodynamic measurements were also performed to analyse the acoustic parameters. Instrumental evaluations included videolaryngostroboscopy (VLS), fibreoptic laryngostroboscopy, flexible laryngoscopy, airflow and volume measurements, maximum phonation time and s/z ratio. In the analysis of voice parameters, computer-assisted acoustic voice analysis programmes, such as the Multi-Dimensional Voice Programme (MDVP) and Customised Praat, are widely used in clinical applications (9, 18).

Another condition associated with sarcopenia is dysphagia. Dysphagia is a condition characterised by disruptions in the movement of food caused by damage to the structures or functions of the masticatory organs (jaw, lips, tongue, soft palate, and throat). This damage can result in serious complications, such as aspiration pneumonia, malnutrition, and, in severe cases, asphyxiation (19). Presbyphagia refers to the common changes in the swallowing process observed in healthy older adults. These alterations can partially diminish the body's natural functional reserve (its capacity to manage physiological stress), increasing the susceptibility of the elderly to dysphagia. Older individuals are more prone to presbyphagia, especially when faced with added stressors such as acute illnesses and medications (20).

Studies have revealed that swallowing disorders are more common in the elderly and that swallowing difficulties significantly affect the quality of life in the geriatric population (21). The older people are at a high risk of dysphagia and other diseases related to ageing. Early detection and support of age-related impairments in swallowing function are important for improving the quality of life of elderly individuals (21, 22). Demir et al. found that the risk of dysphagia increased with age in individuals aged 65 years and older without the development of an additional disorder (21).

There is limited research on the connection between speech acoustic parameters and swallowing function in older adults. Song et al. developed a prediction model for aspiration risk based on speech acoustic parameters (23). Findings from a prospective exploratory study indicated a significant correlation between bedside voice screening results and the objective outcomes of videofluoroscopic swallow studies and fiberoptic endoscopic swallow assessments. Dysphagia and aspiration are associated with abnormal dysphonia (24). Studies have shown that some acoustic parameters may be linked to the swallowing function (25).

Respiratory speech acoustic parameters that can affect swallowing function include maximum phonation time (MPT), subglottic pressure, respiratory rate, apnoea period, and pharyngeal transit time (PDT). In Song et al.'s aspiration risk prediction model for stroke patients with dysphagia, the MPT value might reflect the coordination between speech and breathing, with lower MPT values being associated with a higher risk of aspiration. Subglottic pressure may affect the neural regulation of swallowing by stimulating subglottic mechanoreceptors during swallowing (23). Gross et al. found that the duration of pharyngeal activity was significantly extended when using the residual air volume compared with the total lung volume or functional residual capacity (26). Pharyngeal residence time (PDT) refers to the duration of material remaining in the pharynx before swallowing, either due to a pharyngeal delay or residue from a previous swallow. Morton et al. identified PDT as a key indicator of aspiration risk before and after swallowing in patients with dysphagia following brain injury. Abnormal breathing patterns can also increase the risk of aspiration during swallowing (27).

The aim of this study was to determine the relationship between voice and swallowing by identifying the status of voice and swallowing functions among elderly individuals aged 65 years at risk of sarcopenia. For this purpose, this study investigated whether there was a difference in acoustic and aerodynamic sound parameters between individuals with and without swallowing disorders according to the dysphagia risk score.

MATERIAL AND METHOD

Subjects

In this study, a descriptive research model, which is a quantitative research method, was used. Participation was voluntary, and participants were contacted face-to-face using the snowball technique. The study included 49 individuals (28 women, 21 men) aged 65 years at risk of sarcopenia. The mean age of the participants was 71.04±4.35 years. [range: 82-66]. Participants were administered the SARC-F scale for sarcopenia risk assessment, and those with a score of 4 or above were questioned for other conditions in the study. The other inclusion criteria were age 65 years or older, agreement to participate in the study, not having a diagnosis of swallowing disorder, having a score of 24 or higher on the Standardised Mini Mental Test (MMSE), not having a stroke, and not having a neurodegenerative disease. Participants who did not meet at least one of the following criteria were excluded from the study group. The study was approved by the Ethics Committee and Commissions of Üsküdar University and was conducted in accordance with the Declaration of Helsinki (Date: 28.03.2023, No: 18). All patients met the specified inclusion criteria.

Assessment procedure

Sarcopenia assesment

The Simple Questionnaire to Rapidly Diagnose Sarcopenia (SARC-F) scale was used to determine the risk of sarcopenia. The SARC-F is a self-administered questionnaire used to determine the level of difficulty in five components: strength, walking assistance, getting up from a chair, climbing stairs, and falling. The SARC-F scale scores ranged from 0 to 10 (0=best to 10=worst). A SARC-F score of ≥4 is considered a patient at risk of sarcopenia' (28).

Swallowing assessment

The clinical evaluation of dysphagia was performed using the Eating Assessment Tool 10 (EAT-10). EAT-10 is a self-administered, symptom-specific dysphagia outcome tool that has been used in clinics worldwide and validated in Turkey (29). EAT-10 measures the severity of swallowing disorders, quality of life, and treatment efficacy. The scale comprises 10 questions that are scored between 0 and 4 (0=no problem, 4=serious problem). A total score of 3 or above indicates a risk of swallowing disorders.

Acoustic and aerodynamic voice assessment

Aerodynamic and acoustic sound measurements were used to assess the sound parameters of the participants. Aerodynamic measurements provide an assessment of the airflow and volume for sound production. Among the aerodynamic parameters, the maximum phonation time (MPT) and the S/Z ratio were evaluated. Acoustic analysis was performed using a Lavalier MicroPhone (Model: JH-042) microphone connected to a Lenovo IdeaPad S145 laptop computer equipped with Audacity 3.1.3 software. The microphone was placed 15 cm away from the participant's mouth at a 45° angle with a frequency range of 50-15000 Hz and sensitivity of 30 dB. Because the noise level affects the quality of the audio recording, the audio was recorded in a quiet environment (<30 dB background noise) and in the was format with a sampling rate of 44,100 Hz and 16-bit quantisation. Participants were asked to continuously pronounce the vowels /a/ three times in one breath at a comfortable pitch and loudness level. The sustained /a/ vowel samples were analysed using the Multi-Dimensional Voice Programme (Model 5105; Kay Elemetrics, Co., Lincoln Park, NJ, USA). For the acoustic analysis, a 3-s mid-segment was selected from each sustained vowel (30).

For the aerodynamic analysis, the participants were asked to produce /a/, /s/, and /z/ three times. To measure the maximum phonation time (MPT), participants were asked to breathe deeply and sustain the /a/ sound at a comfortable pitch and loudness for as long as possible. The duration was measured using a stopwatch. To determine the MPT and S/Z ratio, measurements were recorded three times, and the longest phonation time measured in seconds was accepted.

Statistical analysis

Statistical Package for the Social Sciences (IBM SPSS Corp., Armonk, NY, USA) 25 software was used in the statistical analysis of the scale and voice analysis findings obtained from data analysis. The descriptive statistics of the variables are presented as the number of participants (n), number of responses (f), and percentage (%). The descriptive statistics of the continuous variables are presented as mean ±standard deviation. Whether the scores on all scales were normally distributed was determined by the Shapiro–Wilk test, and Spearman correlation analysis was used in the correlation analysis because all scale scores were not normally distributed. Correlation coefficients between 0.05 and 0.30 indicate low

Table 1: Comparison of the demographic and clinical characteristics between patients with and without dysphagia

	Overall (n=49) x̄ ±SD	Dysphagic (n=29) x̄ ±SD	Non-Dysphagic (n=20) x̄ ±SD	p
Age	71.04±4.35	71.51±3.39	70.35±3.19	0.07
Gender (F/M)	28 (57.1%)/21 (42.9%)	19 (67.8%)/10 (47.6%)	9 (32.2%)/11 (52.4%)	0.15
EAT-10	5.12±6.52	7.97±7.99	1.15±1.08	**0.001****
SARC-F	3.83±2.57	5.03±2.92	3.2±2.13	0.20

EAT-10: Eating Assessment Tool, SARC-F: A Simple Questionnaire to Rapidly Diagnose Sarcopenia x̄: Mean, SD: Standard Deviation. *p<0.05, **p<0.01 is considered statistically significant.

Table 2: Voice analysis results for the sustained vowel /a/ in the dysphagic and nondysphagic groups

MDVP	Dysphagic group (n=29)			Non-Dysphagic group (n=20)					
	Mean±SD			Mean±SD			p	p	p
	Male	Female	Overall	Male	Female	Overall	Male (n=21)	Female (n=28)	Overall (n=49)
Fundamental Frequency									
F0 (Hz)	157.9±27.7	235.6±48.2	208.8±36.2	155.2±35.2	224.0±53.5	186.2±25.6	0.918	1.000	**0.011***
Frequency perturbation parameters									
Jitt (%)	0.91±0.49	1.09±0.84	1.03±0.73	0.86±0.52	1.09±0.53	0.97±0.53	0.756	0.664	0.976
RAP (%)	0.54±0.30	0.64±0.47	0.60±0.42	0.51±0.33	0.65±0.34	0.57±0.33	0.705	0.699	0.976
PPQ (%)	0.53±0.29	0.65±0.52	0.60±0.45	0.52±0.35	0.63±0.30	0.57±0.32	0.888	0.699	0.927
Amplitude perturbation parameters									
Shim (%)	4.74±1.9	4.13±1.73	5.13±1.34	4.60±1.81	5.61±2.82	4.29±1.74	0.605	0.243	**0.043***
APQ (%)	4.40±1.76	3.61±1.50	4.44±2.23	3.88±1.57	4.50±2.81	3.70±0.28	0.251	0.772	0.077
vAm (%)	26.7±11.6	28.2±10.7	27.71±2.01	24.7±9.32	24.1±15.1	24.46±8.02	0.918	0.357	**0.037***
Noise parameters									
NHR	0.15±0.05	0.13±0.02	0.14±0.04	0.13±0.01	0.13±0.02	0.13±0.02	0.205	0.980	0.230
VTI	0.04±0.03	0.04±0.01	0.04±0.02	0.04±0.01	0.03±0.01	0.04±0.01	0.307	0.325	0.919
SPI	15.0±21.3	13.2±10.8	13.91±8.94	13.8±11.1	6.22±3.59	10.43±4.28	0.387	**0.028***	0.070
Tremor parameters									
ATRI (%)	9.90±5.02	8.98±5.14	9.34±4.90	9.12±4.89	8.68±8.50	8.93±6.38	0.833	0.662	0.650
FTRI (%)	0.61±0.36	0.84±0.47	0.75±0.11	0.60±0.48	0.48±0.33	0.54±0.08	0.888	**0.046***	**0.001****
Subharmonics parameters									
DSH (%)	0.40±0.86	1.92±2.83	0.97±2.09	0.19±0.65	0.77±1.39	0.64±1.23	0.525	0.168	0.666
Voice break-related parameters									
DVB (%)	0.01±0.02	0.84±2.61	0.55±2.13	0.00±0.01	0.78±2.36	0.36±1.58	0.391	1.000	0.748
NVB	0.09±0.30	0.77±2.33	0.40.1.56	0.00±0.01	0.10±0.31	0.06±1.56	0.391	0.927	0.684
Aerodynamic parameters									
MPT	5.70±2.75	4.10±2.07	4.65±2.40	0.82±0.27	9.77±5.69	9.90±3.67	**0.037***	**0.003****	**0.001****
S/Z	0.83±0.23	0.93±0.51	0.87±0.41	0.82±0.28	0.89±0.29	0.87±0.27	1.000	0.801	0.861

F0: Fundamental frequency, Jitt: Jitter, RAP: Relative average perturbation, PPQ: Pitch perturbation quotient, Shim: Shimmer, APQ: Amplitude perturbation quotient, vAm: Amplitude variation, NHR: Noise harmonic ratio, VTI: Voice turbulent index, SPI: Soft phonation index, ATRI: Amplitude tremor intensity index, FTRI: Frequency tremor intensity index, DSH: Degree of subharmonics, DVB: Degree of voice breaks, NVB: Number of voice breaks, MPT: Maximum phonation Time. *p<0.05, **p<0.01 is considered statistically significant.

Table 3: Relationship between the EAT-10 and SARC-F scores and voice parameters

Acoustic parameters		EAT-10	SARC-F
Jitter	r	-0.154	0.035
	p	0.435	0.860
Shimer	r	-0.297	-0.091
	p	0.125	0.644
NHR	r	-0.116	0.199
	p	0.556	0.309
vAM	r	0.302	-0.064
	p	0.118	0.747
SPI	r	**0.409**	-0.021
	p	**0.031***	0.914
ATRI	r	0.170	0.244
	p	0.561	0.401
FTRI	r	**0.416**	0.026
	p	**0.048***	0.905
DSH	r	-0.363	0.052
	p	0.057	0.792
DVB	r	-0.015	0.177
	p	0.941	0.369
Aerodynamic parameters			
MPT	r	**-0.650**	-0.117
	p	**0 .001****	0.552
S/Z	r	-0.112	-0.129
	p	0.572	0.513

*p<0.05, **p<0.01 is considered statistically significant. NHR: Noise harmonic ratio, vAm: Amplitude variation, SPI: Soft phonation index, ATRI: Amplitude tremor intensity index, FTRI: Frequency tremor intensity index, DSH: Degree of subharmonics, DVB: Degree of voice breaks, MPT: Maximum phonation time.

correlation, between 0.30 and 0.40 indicate low-moderate correlation, between 0.40 and 0.60 indicate moderate correlation, between 0.60 and 0.70 indicate good correlation, between 0.70 and 0.75 indicate strong correlation and between 0.75 and 1.00 indicate excellent correlation (31). Mann-Whitney U test was used for intergroup comparison. In all statistical analyses, significance was evaluated at p<0.05 level.

RESULTS

The study included 49 people aged 65 years at risk of sarcopenia. Participants were divided into two groups according to their EAT-10 scores with and without dysphagia. Of the participants, 29 (59.19%) were in the dysphagia group and 20 (40.81%) were in the nondysphagic group. The mean age of the patients in the dysphagic group was 71.51±3.39, while the mean age of the patients in the non-dysphagic group was 70.35±3.19 years. The mean EAT-10 score of the dysphagic group was 7.97±7.99, the mean SARC-F score was 5.03±2.92, the mean EAT-10 score of the non-dysphagic group was 1.15±1.08, and the mean SARC-F score was 3.2±2.13. There were no statistically significant differences in age, gender, and SARC-F scores between the two groups. This indicates that the participants were homogeneously distributed among the groups. The demographic and clinical characteristics of the participants are presented in Table 1.

Acoustic sound measurements were analysed between the dysphagic and non-dysphagic groups, and the results of the sound parameters obtained using MDVP are presented in Table 2.

According to the results of the acoustic analysis performed with MDVP, a statistically significant difference was found between the two groups in the mean fundamental frequency (F0) parameter when the group was compared with the non-dysphagic group (p=0.011). However, no significant difference was found between the two groups according to gender.

In all frequency perturbation parameters (Jitter, RAP and PPQ), there was no statistically significant difference between the dysphagic and non-dysphagic groups.

Regarding the amplitude perturbation parameters Shimmer and vAm, a statistical difference was found between the dysphagic and non-dysphagic groups (p=0.043, 0.037). However, no significant difference was found between the two groups in terms of gender. For the APQ parameter, another amplitude perturbation parameter, no significant difference was found between the groups.

Although there was no significant difference between the groups in the noise parameters NHR and VTI, in the SPI parameter, a statistically significant difference was found between the dysphagic and non-dysphagic group in women (p=0.028).

There were no significant differences in ATRI among the tremor parameters. However, when the dysphagic group was compared with the nondysphagic group regarding the FTRI parameter, a statistical difference was found between the two groups (p=0.001). In the comparisons according to gender, a significant difference was found in the dysphagic female group (p=0.046), whereas no significant difference was observed between male participants in the same parameter.

The degree of subharmonic (DSH), which is one of the subharmonic parameters, was higher in both the total values and in the male and female dysphagic groups compared with the nondysphagic group, but did not show a significant difference.

There were no significant differences between the groups in the degree of voice breaks (DVB) and Number of voice breaks (NVB).

The MPT value, one of the aerodynamic parameters, a statistical difference was found between the dysphagic group and the non-dysphagic group (p=0.001). In the comparisons according to gender, a significant difference was found between the two groups in both the female and male participants (p=0.003, p=0.037). Another aerodynamic measure, the s/z Ratio, showed no significant difference between the groups.

The relationship between the EAT-10 and SARC-F scores and the acoustic and aerodynamic sound parameters of the participants included in the study was analysed, and the results are presented in Table 3.

Accordingly, a statistically significant, positive, moderate correlation was found between EAT-10 and the acoustic parameters SPI and FTRI (r=0.409; p=0.031, r=0.416; p=0.048). Among the aerodynamic parameters, a statistically significant, negative, good correlation was found between MPT and EAT-10 (r=-0.650; p=0.001). Accordingly, the MPT scores decreased as the severity of the swallowing disorder increased.

No significant correlation was observed for the remaining parameters. There was also no statistically significant relationship between the voice parameters and SARC-F.

DISCUSSION

It has been shown that voice quality deteriorates markedly with ageing in older people, and this is associated with a decrease in muscle mass. Another affected function is swallowing. These findings indicate that voice and swallowing disorders are common in individuals at risk of sarcopenia (32). The current study investigated the relationship between voice and swallowing by determining the status of voice and swallowing functions among elderly individuals aged 65 years at risk of sarcopenia. Acoustic and aerodynamic sound parameters were examined between individuals with and without swallowing disorders according to dysphagia risk scores and whether there was a difference between the groups.

According to the results of our study, dysphagia was observed in approximately 60% of the participants at risk of sarcopenia and over the age of 65. Yoshikawa et al. stated that impairments in the swallowing function in elderly individuals are a natural consequence of ageing and that these impairments negatively affect the nutritional and general health status. It is noted that voice and swallowing disorders, which share a common anatomy with muscle mass loss in individuals at risk of sarcopenia, may be more prevalent and severe (33). In a study involving participants aged 65 years and older at risk of sarcopenia, dysphagia was found in more than half of the participants, supporting these findings. Research has demonstrated a strong association between sarcopenia and dysphagia. Sarcopenia is characterised by reductions in muscle mass and strength, which can result in the weakness of the muscles involved in swallowing function (34). In a 2021 study, Çolak et al. explored the connection between sarcopenia and dysphagia in greater detail and demonstrated that muscle mass loss in elderly individuals can significantly impair swallowing function, increasing the risk of aspiration (32).

According to our acoustic sound analysis, the Fundamental Frequency (F0) parameter was notably lower in the dysphagic group. Rajappa et al. found that reduced F0 values were linked to impaired swallowing function and weakened airway protection (35). Our findings, which revealed a significant decrease in the F0 parameter in the dysphagic group, support the association between low F0 values, poorer swallowing function, and a higher risk of aspiration.

Our study results indicated that the amplitude perturbation parameters, shimmer and vAm, were significantly higher in the dysphagic group. These parameters reflect the control of the loudness and its variability. The amplitude is directly related to the air pulsations from the glottis and the sound pressure. When the vocal cords do not close properly and there is inadequate breath support for voice production, there is an increase in the deterioration of these parameters (36-39).

In studies examining acoustic sound parameters to predict dysphagia, the shimmer parameter was identified as a key indicator of aspiration risk. Ryu et al. found that the shimmer values were higher in patients at high risk of aspiration than in those at low risk (40). In research focused on voice parameters for detecting dysphagia in patients with multiple sclerosis, shimmer was reported to be significantly elevated in dysphagic individuals (41). Song et al. also noted a significant correlation between Shimmer values and silent aspiration in 55 participants with suspected dysphagia (42). The vAm parameter related to breath control may indicate incomplete closure of the vocal cords. The incomplete closure of the vocal cords can compromise airway safety and may also contribute to aspiration and swallowing disorders. These findings indicate that vocal vibrations and changes in the amplitude of the voice are more pronounced in individuals with dysphagia and that these changes may be related to the swallowing function. Shimmer and vAm parameters have been reported to be associated with dysphagia in many stupidity (36-42).

Another result of our study was that the SPI values of female individuals with dysphagia were significantly higher. The SPI parameter is related to the tenseness of the vocal cords during phonation and whether they are fully closed. The SPI parameter increases when the vocal cords are loosely or incompletely closed during phonation (36). Higher SPI values, particularly in women, are correlated with increased posterior glottal chink opening in women (42). In this context, the finding of a higher SPI value in women in relation to gender differences is supported by other studies in the literature.

In our study, acoustic sound analysis revealed that the FTRI parameter was significantly higher in the dysphagic group, including in women. The FTRI parameter assesses voice quality and stability by measuring the transgluteal resistance of the vocal cords, which increases when tremors are present during vocal cord vibration (43). The FTRI reflects more pronounced tremor changes in individuals with dysphagia, suggesting its utility as an effective indicator of voice changes related to dysphagia. It has been noted that FTRI is a crucial parameter for detecting tremors associated with dysphagia and should be carefully considered in voice analysis studies (43).

In our study, MPT values were statistically significantly lower in both the overall participant group and the dysphagic subgroup, according to gender. Additionally, a statistically significant negative correlation was observed between MPT and EAT-10, indicating that MPT scores decreased as the severity of the swallowing disorder increased. MPT was used to measure the continuity of the vocal cord function during voice production (39). High MPT values indicate that the vocal cords are strong and healthy, whereas low MPT values indicate that there is insufficient closure in the vocal cords or phonation process (39). This indicates that swallowing disorders may have an indirect effect on phonation duration. MPT is also a parameter that provides an idea of the respiratory capacity. Respiration is temporarily stopped during swallowing, and this mechanism protects the airways (44). The coordination between breathing and swallowing is coordinated by nerve centres in the brain stem. This coordination is critical for healthy digestive and respiratory functions (45). MPT is considered a respiratory speech acoustic parameter that may affect the swallowing function (25). Song et al. reported that a low MPT was associated with a high risk of aspiration (46). In a study examining the relationship between swallowing function and MPT in patients with Parkinsonism, impaired swallowing function was found to cause a significant decrease in MPT by affecting the continuity of the voice (47). Similarly, in another study that examined the relationship between swallowing function and respiration and phonation, MPT was found to play an important role in the coordination of respiratory and swallowing functions (48). In this context, the significant decrease in MPT duration observed in the dysphagic participants in our study supports these findings.

There are some limitations in our study. First, the lack of a control group that included participants aged who were not at risk of sarcopenia was one of the important limitations of the study. Another limitation of our study is that acoustic measurements were performed only for extended phonation. In addition to frequency-based measurements, spectral and cepstral measurements that allow sound analysis in connected speech may provide a more comprehensive evaluation.

CONCLUSION

Overall, this study emphasises the importance of assessing voice and swallowing function in elderly individuals at risk of sarcopenia and provides information for the early detection of impairments in these areas. This study compared the acoustic and aerodynamic voice analysis parameters between the two groups with and without dysphagia. The results suggest that reduced respiratory support and control, vocal fold closure, and airflow control deficits during vocal fold adduction are risk factors for dysphagia in the elderly population. The findings highlight the importance of monitoring and managing the voice and swallowing functions in clinical practise.

Ethics Committee Approval: This study was approved by the Ethics Committee of the Üsküdar University (Date: 28.03.2023, No: 18).

Informed Consent: Written informed consent was obtained from all participants who participated in this study.

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