



CLINICAL STUDY

INVESTIGATION OF DYSPHAGIA LIMIT OUTCOMES IN HEALTHY YOUNG ADULTS: AN OBSERVATIONAL-DESCRIPTIVE STUDY

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SUMMARY

Objective: Dysphagia Limit (DL) is an electrophysiological assessment tool used in swallowing evaluations. The main objective of this study was to examine DL findings in healthy young adults aged 18-25 years.

Material and Methods: A total of 100 individuals (50 males and 50 females) were included in the study. During DL measurements, each participant underwent swallowing trials using thin liquid in 5 mL increments (5, 10, 15, 20, 25, 30 mL, etc.), while submental surface electromyography (sEMG) recordings were simultaneously recorded. When a secondary swallow and/or aspiration sign was observed in the sEMG trace, the trial was terminated and the corresponding volume was recorded as the DL.

Results: No statistically significant difference was observed between the ages of male and female participants ($z = -0.428$, $p = 0.668$). The median (min-max) DL was 30 (20-55) mL in all participants, 37.5 (20-55) mL in males, and 30 (20-50) mL in females. A significantly higher DL finding was detected in males compared to females ($z = -3.719$, $p < 0.001$). A weak but statistically significant positive correlation was found between body mass index (BMI) and DL in all individuals ($r = 0.212$, $p = 0.046$).

Conclusion: DL reference values were established for the first time in a healthy young adult population, and it was demonstrated that DL may be influenced by variables such as gender and BMI. The current findings were considered to be important for both clinical evaluation processes and future research.

Keywords: Dysphagia limit, electrophysiological measurement, deglutition disorders

SAĞLIKLI GENÇ YETİŞKİNLERDE DİSFAJİ LİMİT BULGULARININ ARAŞTIRILMASI: GÖZLEMSEL-TANIMLAYICI BİR ARAŞTIRMA

ÖZET

Amaç: Disfaji Limit (DL), yutma değerlendirmelerinde kullanılan elektrofizyolojik bir değerlendirme aracıdır. Bu çalışmadaki temel amacımız, 18-25 yaş arası sağlıklı genç yetişkinlerde DL bulgularını incelemektir.

Gereç ve Yöntemler: Çalışmaya toplam 100 birey (50 erkek ve 50 kadın) dahil edilmiştir. DL ölçümlerinde her katılımcıya 5 mL'lik artışlarla (5, 10, 15, 20, 25, 30 mL, vb.) ince sıvı ile yutma denemeleri yapılırken eşzamanlı olarak submental yüzeysel elektromiyografi (yEMG) kayıtları incelenmiştir. Yutma esnasında yEMG'ye yansıyan ikincil yutma varlığında ve/veya aspirasyon belirtisinde yutma denemeleri durdurulmuş ve ilgili volüm DL olarak kayıt edilmiştir.

Bulgular: Erkek ve kadın katılımcıların yaşları arasında istatistiksel olarak anlamlı fark gözlenmemiştir ($z = -0.428$, $p = 0.668$). Ortanca (min-max) DL bulgusu tüm katılımcılarda 30 (20 - 55) mL, erkeklerde 37.5 (20 - 55) mL ve kadınlarda 30 (20 - 50) mL olarak bulundu. Erkeklerde kadınlara göre istatistiksel olarak anlamlı derecede daha yüksek DL bulgusu saptanmıştır ($z = -3.719$, $p < 0.001$). Tüm bireylerde vücut kitle indeksi (VKİ) ile DL arasında pozitif yönde zayıf derecede istatistiksel olarak anlamlı bir ilişki bulunmuştur ($r = 0.212$, $p = 0.046$).

Sonuç: DL referans değerleri genç yetişkin popülasyon için ilk kez ortaya konulmuş ve DL'nin cinsiyet ve VKİ gibi değişkenlerden etkilenebileceği gösterilmiştir. Mevcut bulguların hem klinik değerlendirme süreçleri hem de ileri araştırmalar açısından önemli bir katkı sunacağı düşünülmüştür.

Anahtar Sözcükler: Disfaji limit, elektrofizyolojik ölçüm, yutma bozuklukları

INTRODUCTION

Dysphagia is a clinical symptom characterized by swallowing difficulties resulting from disorders affecting anatomical regions from the oral cavity to the stomach.¹ Swallowing is

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a complex activity involving at least 20 muscles and several cranial nerves.^{2,3} Neurological diseases, head and neck cancers, traumatic brain injuries, systemic diseases, gastroesophageal reflux, and esophageal motility disorders are among the major etiologies leading to dysphagia.⁴ Owing to its associated morbidity and mortality, accurate diagnosis and treatment of dysphagia are crucial for patient health. Comprehensive evaluation plays a key role in determining an appropriate treatment plan, as incomplete or inappropriate assessment may result in dehydration, malnutrition, respiratory infections, or even death.⁵ Additionally,



dysphagia significantly reduces quality of life, affecting social and psychological well-being and often leading to social isolation and anxiety.⁶

Fiberoptic Endoscopic Evaluation of Swallowing (FEES) and Modified Barium Swallow Study (MBSS) are internationally accepted and commonly used gold standard methods in swallowing assessment.⁷ However, both methods have inherent limitations. MBSS involves radiation exposure, (can not) detect neuromuscular abnormalities of the laryngeal or pharyngeal regions, and is costly and time-consuming. FEES requires complex equipment, may cause discomfort, (can not) assess the oral phase, and is also time-consuming and expensive.⁸ These limitations have encouraged researchers and clinicians to explore reliable, non-invasive, cost-effective, and easily applicable clinical tools for swallowing assessment.

Surface electromyography (sEMG) has long been used in the evaluation of swallowing disorders.⁹⁻¹² One of the most widely studied electrophysiological tools, developed by Ertekin et al.¹³ is the Dysphagia Limit (DL) which is defined as the smallest bolus volume that (can not) be swallowed in a single attempt and requires two or more swallows to complete. Previous studies have demonstrated that the DL method is a reliable screening tool for identifying swallowing disorders across various patient groups.¹⁴⁻¹⁷ In one study (20 men and 10 women, mean age = 43.0 ± 17.6), Ertekin et al.¹³ reported that healthy individuals could swallow boluses up to 20 mL in a single attempt, establishing 20 mL as the DL threshold. Another study conducted by Ertekin et al.¹⁸ included a total of 252 participants, consisting of 75 healthy individuals and 177 patients diagnosed with neurogenic dysphagia, to evaluate DL findings. The healthy participants were examined in three distinct age categories (17-39, 40-59, and 60-81 years), and DL findings greater than 20 mL were observed in all groups. However, the aforementioned studies did not provide clear data regarding the mean or median values of DL findings within these age groups. Furthermore, a review of the literature revealed no studies that accurately reflected DL findings specifically in the young adult population (18-25 years).

Due to the alterations in the neurophysiology of swallowing associated with aging, swallowing kinematics also differ across age groups.^{19,20} Although dysphagia is known to increase with advancing age, it should be noted that this symptom may occur in all age groups as a result of various pathological conditions.^{4,21,22} In the young adult population, numerous mechanical or obstructive clinical conditions, primarily caused by immunological or gastroesophageal factors, may lead to swallowing disorders.^{4,23} Therefore, the age factor should always be taken into account when determining normative values specific to swallowing assessment methods²⁴. Furthermore, establishing age-specific normative data for swallowing disorders, objectively evaluating swallowing function at an early stage, and using sensitive measurements to detect dysphagia risk are all crucial for both screening and early diagnosis.

In light of current knowledge, previous studies have generally reported DL findings only as values greater than 20 mL, without providing clear evidence regarding the mean or median DL values. Moreover, no study has been found investigating DL normative data across different age groups. Accordingly, the present study aims to investigate the DL method-an electrophysiological tool for swallowing assessment-in healthy young adults (18-25 years) and to provide reference values for the DL parameter within this population.

MATERIAL and METHODS

This observational-descriptive study was conducted in the Department of Speech and Language Therapy at Gazi University. Ethical approval was obtained from the Gazi University Ethics Committee (approval code: 2025-848). All participants provided written informed consent prior to participation, and the study was carried out in accordance with the principles of the Declaration of Helsinki.

Participants

The study included 100 participants (50 males and 50 females) aged 18-25 years with no swallowing-related complaints and normal swallowing function. Height and weight were measured for all participants to calculate BMI. Exclusion criteria included a history of head and neck surgery (excluding septoplasty and



rhinoplasty), cardiac disorders, active pacemaker or other electronic implants, epilepsy, systemic or endocrine disorders (i.e., diabetes mellitus, Sjögren's syndrome) causing xerostomia, and inability to comply with the study protocol.

Electrophysiological Assessment (Dysphagia Limit)

Electrophysiological recordings were obtained using the sEMG protocol of the VitalStim Plus (Chattanooga Group, Hixson, TN) system. A pair of surface electrodes (Chattanooga VitalStim Plus Electrodes) was placed horizontally and bilaterally on the submental region along the midline, with a reference electrode placed over the trapezius muscle (Figure 1). Before electrode placement, the submental region was shaved in male participants, and related skin areas were cleaned with 70% alcohol.

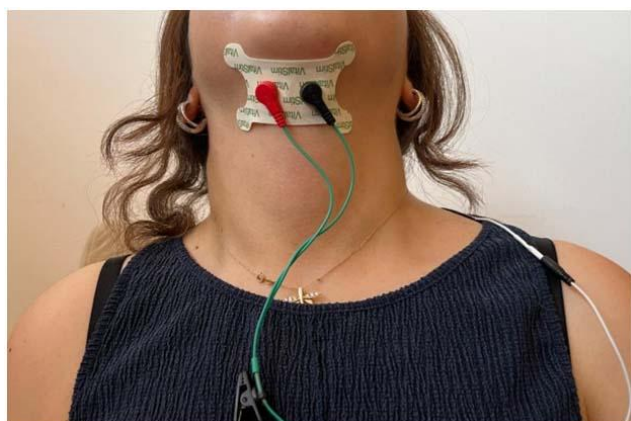


Figure 1: Electrode placements during DL measurements

During the DL measurements, each participant's head was positioned upright and comfortably while seated, and they were instructed to maintain this posture throughout the assessment. After completing the electrode placements, the sEMG signals were integrated into a personal computer and monitored simultaneously. After ensuring that all electrodes had good surface contact with the skin, it was confirmed that the basal submental sEMG activation signals observable on the integrated system interface were below 5 mV.^{12,25} Subsequently, swallowing trials were initiated by selecting the *Start* tab in the window opened via the *Open Display* option. The relevant interface allowed the examiner to stop (*Pause*) or resume

(*Continue*) the sEMG signal recording as needed. After the swallowing trials were completed, the recordings were saved to the interface database under the corresponding participant code using the *Finish* and *Save* options, respectively.

Swallowing trials began with the administration of 5 mL of thin liquid (distilled water at room temperature) to each participant and continued with gradual 5 mL increments (5, 10, 15, 20, 25, 30 mL, etc.). Participants were instructed to hold the bolus in their mouth and swallow it upon receiving the "swallow" command from the examiner. The sEMG signals for each swallowing trial were monitored for 8 seconds.

As shown in Figure 2, if any signs of secondary swallowing and/or aspiration symptoms were observed during the specified time period, the swallowing trials were terminated, and the corresponding volume was recorded as the DL value. Secondary swallows were considered as the distinct bursts of submental sEMG activity occurring within the 8-second observation window following the initial swallow. Aspiration-related symptoms were defined as coughing, throat clearing, or wet voice quality observed after swallowing. After each swallowing trial and the subsequent 8-second observation period, a minimum rest interval of 30 seconds was provided. The data were collected by four researchers who were undergraduate students in Speech and Language Therapy, under the supervision and guidance of two speech and language therapists with 10 years of experience in the field of swallowing disorders. The present DL procedure was implemented in accordance with the protocol described by Ertekin et al.¹³



Figure 2: sEMG signals of a participant whose DL volume was determined as 30 mL



Statistical Analysis

Data analysis was conducted using the Statistical Package for the Social Sciences (SPSS, version 25.0, Chicago, IL). The normality of continuous variables was assessed using visual (histograms, Q-Q plots) and analytical methods (Kolmogorov-Smirnov and Shapiro-Wilk tests). Age, BMI, and DL were non-normally distributed and presented as median (min-max) values. Between-group comparisons were performed using the Mann-Whitney U test. Correlation between DL and BMI was examined using Spearman's correlation analysis. A p -value < 0.05 was considered statistically significant for the current study.

To support the adequacy of the sample size for secondary gender-based analyses, a post hoc power analysis based on the observed difference in DL values between males and females (Mann-Whitney U test, $z = -3.719$, $p < 0.001$; effect size $r = 0.37$) demonstrated that, with a two-tailed alpha level of 0.05, the inclusion of 100 participants (50 per group) provided a statistical power exceeding 0.95 (G*Power version 3.1.9.7).

RESULTS

The median (min-max) age of all participants included in the study was 21 (18-24) years. The median (min-max) age for both male and female groups was also 21 (18-24) years, with no statistically significant difference observed between genders ($z = -0.428$, $p = 0.668$). The median (min-max) BMI value for all participants was 22.9 (15.2-38.6), while the median (min-max) BMI was 24.1 (18.9-38.6) in males and 20.4 (15.2-31.7) in females. The comparison by gender revealed that males had significantly higher BMI values than females ($z = -4.345$, $p < 0.001$).

The median (min-max) DL finding for all participants was 30 (20-55) mL. When compared by gender, the median (min-max) DL value was 37.5 (20-55) mL in males and 30 (20-50) mL in females (Table 1). The comparison indicated that males had significantly higher DL values than females ($z = -3.719$, $p < 0.001$) (Figure 3).

When examining the relationship between BMI and the DL parameter for all participants, a weak but statistically significant positive correlation was found between the two parameters ($r = 0.212$, $p = 0.046$) (Figure 4).

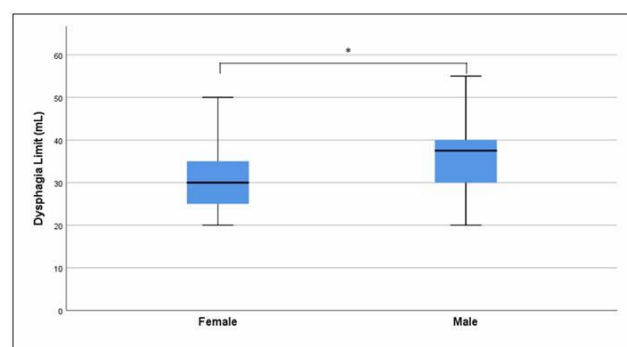


Figure 3: DL findings by gender

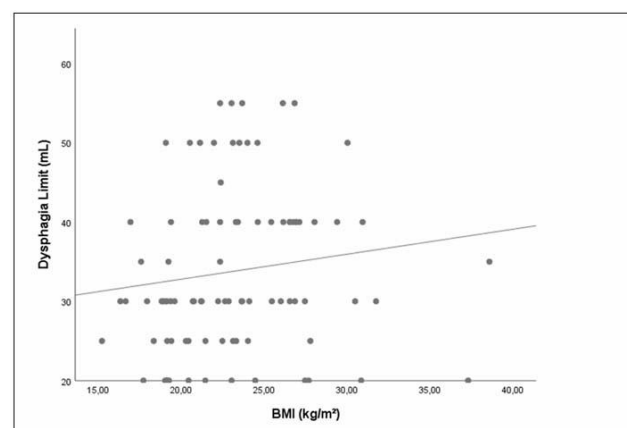


Figure 4: Relationship between DL and BMI parameters

Table 1. General characteristics and DL findings of participants

Parameters	All Participants (n=100)	Male (n=50)	Female (n=50)	p-value
	Median (min-max)	Median (min-max)	Median (min-max)	
Age (years)	21 (18 – 24)	21 (18 – 24)	21 (18 – 24)	0.668
BMI (kg/m ²)	22.9 (15.2 – 38.6)	24.1 (18.9 – 38.6)	20.4 (15.2 – 31.7)	<0.001
DL (mL)	30 (20 – 55)	37.5 (20 – 55)	30 (20 – 50)	<0.001

Abbreviations: BMI, body mass index; DL, dysphagia limit; mL, milliliter



DISCUSSION

In the present study, the median DL value for healthy individuals aged 18-25 years was found to be 30 mL (min-max = 20-55), and the DL values were significantly higher in males compared to females. Additionally, a weak but statistically significant positive correlation was observed between participants' BMI and DL findings.

A review of the literature revealed that studies investigating DL findings in healthy individuals without any swallowing disorder are limited. In this context, in a study conducted by Ertekin et al.,¹³ DL findings of 30 healthy individuals (20 males and 10 females) aged between 20 and 71 years (mean \pm SD = 43.0 \pm 17.6) were reported to range between 25 and 40 mL. Similarly, in another study by Ertekin et al.,¹⁸ DL findings were examined in a total of 252 participants, including 75 healthy individuals and 177 patients diagnosed with neurogenic dysphagia. The healthy participants were divided into three age groups: young (17-39 years, N = 38, mean age = 27.8 years), middle-aged (40-59 years, N = 17, mean age = 50.2 years), and elderly (60-81 years, N = 20, mean age = 69.2 years). In all age groups, the DL volume was reported to be above 20 mL. In a study conducted by Selçuk et al.,²⁶ the effect of thin liquid (water) at different temperatures on swallowing physiology was investigated using the DL method. Among 40 healthy participants (23 males and 17 females) with a mean \pm SD age of 47.9 \pm 15.6 years, DL values were found to be above 20 mL in all individuals, with an average DL of 30.5 \pm 7.8 mL for water at room temperature. Consistent with previous findings, the present study also found that DL volumes were above 20 mL in all participants; however, the maximum DL volume reached up to 55 mL. The reason for the DL volume reaching up to the level of 55 mL might be that our study was conducted with a younger population compared to previous studies. It is known that with increasing age, coordination of the swallowing reflex, swallowing capacity, and the volume/thickness of swallowing muscles tend to decrease.^{27,28} This could explain the higher DL volumes found in the young adult population

examined in this study. Moreover, previous studies did not provide any mean or median DL values specific to a defined age group (18-25 years), making direct comparisons difficult. Additionally, technical differences exist between studies regarding the sEMG equipment used for DL measurement. Therefore, although this study provides specific normative DL values for young adults, the results should be interpreted with caution.

When DL findings were compared by gender, males showed significantly higher DL volumes (median = 37.5 mL) than females (median = 30 mL). This difference may be related to the larger oropharyngeal structures in males^{29,30} and their greater suprahyoid muscle strength compared to females.^{31,32} Supporting this, Colevas et al.³³ reported a statistically significant relationship between male gender and increased self-selected swallow volume. To the best of our knowledge, this study is the first to compare DL volumes by gender, suggesting that the influence of sex on swallowing volume should be considered in diagnostic evaluations.

A weak but statistically significant positive correlation was also found between BMI and DL values. Accordingly, as BMI increased, DL also showed a slight increase. Previous research has demonstrated a significant association between BMI and muscle mass, indicating that individuals with lower BMI are at higher risk of reduced muscle mass, while those with higher BMI have lower risk.³⁴⁻³⁶ These findings suggest that an increase in overall muscle mass, including the submental muscle group, may lead to higher DL volumes. Therefore, the weak positive correlation between BMI and DL found in this study is consistent with the literature. Future studies using methods that directly assess isolated muscle mass rather than BMI could provide a more accurate understanding of the relationship between DL parameters and muscle mass.

Although the present study was designed to align methodologically with previous literature, several limitations should be noted. First, using measurement techniques that provide more specific information about body and



submental muscle mass-rather than BMI-could enable a more accurate evaluation of the relationship between DL and muscle mass. Second, DL measurements in this study were obtained using the sEMG protocol of the VitalStim Plus device. Although this device provides information on submental muscle activation and duration, the use of more specialized sEMG equipment may be beneficial to confirm the findings. Lastly, this study only reported DL findings for a young adult population. Given the scarcity of research presenting normative DL values across different age ranges and sexes, future studies investigating DL volumes in diverse age and gender groups would be highly valuable.

CONCLUSION

This study is the first to examine DL findings in healthy young adults and to present normative reference values for this population. The results revealed that DL volumes differ between genders and may vary in relation to individuals' BMI. Comparing the reference values obtained from young adults with data from individuals with swallowing disorders could provide valuable insights for both clinical swallowing assessments and future dysphagia research. Further studies with larger sample sizes are needed to generalize the present findings.

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