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ARAŞTIRMA / RESEARCH

Turkish normative data for the Test of Masticating and Swallowing Solids (TOMASS)

Katıları Çiğneme ve Yutma Testi'nin Türkiye normatif verileri

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Abstract

Purpose: Swallowing is a complex neuromuscular process requiring the integrity of many muscles and nerves. The natural aging process can result in deterioration of the swallowing structures and result in functional changes in healthy older adults. The Test of Masticating and Swallowing Solids is the only non-instrumental test that provides quantitative measures for solid food ingestion. This study aimed to establish normative data for the Test of Masticating and Swallowing Solids in healthy Turkish adults to potentially serve as a standard in dysphagia evaluation.

Materials and Methods: A total of 144 healthy Turkish adults (ages 20-80+ years) grouped by age and gender participated in this study. The test required participants to eat a regional cracker. Per the protocol, the number of masticatory cycles, number of swallows, number of bites, and total duration to eat the cracker were recorded.

Results: Normative data were obtained for the Test of Masticating and Swallowing Solids from 144 healthy adults, stratified by age and gender. Younger participants took fewer bites (2.00 versus 2.65), chewed less (34.50 versus 51.02), swallowed less (2.06 versus 3.39), and swallowed quicker (30.14 versus 49.20) than older participants. In terms of gender, males took fewer bites (1.94 versus 2.59), chewed less (40.98 versus 45.83), and swallowed quicker (36.72 versus 41.23) than females.

Conclusion: The Test of Masticating and Swallowing Solids is a quick, sensitive, and objective measure of solid bolus ingestion that may be useful for identifying dysphagic patients at bedside and for tracking the efficiency of the oral phase of swallowing.

Keywords:. assessment, mastication, deglutition, normative

Öz

Amaç: Yutma, birçok kas ve sinirin bütünlüğünü gerektiren karmaşık bir nöromüsküler süreçtir. Doğal yaşlanma süreci, yutma yapılarının bozulmasına ve sağlıklı yaşlı yetişkinlerde fonksiyonel değişikliklere neden olabilir. Katıları Çiğneme ve Yutma Testi, katı gıda yenmesinde kantitatif ölçümler sağlayan tek enstrümental olmayan testtir. Bu çalışma, sağlıklı Türk yetişkinlerinde potansiyel olarak klinik disfaji değerlendirmesinde standart görevi görebilecek olan Katıları Çiğneme ve Yutma Testi için normatif verileri oluşturmayı amaçlamaktadır.

Gereç ve Yöntem: Çalışmaya yaş ve cinsiyete göre gruplandırılmış 144 sağlıklı Türk yetişkini (20-80 yaş arası) katılmıştır. Test, katılımcıların bölgesel bir kraker yemesini gerektirdi. Protokole göre çiğneme döngüsü sayısı, yutma sayısı, ısırık sayısı ve krakeri yutmak için toplam süre kaydedildi.

Bulgular: Katıları Çiğneme ve Yutma Testi için normatif veriler, bölgesel bir kraker için yaş ve cinsiyete göre gruplandırılmış 144 sağlıklı kontrolden elde edildi. Daha genç katılımcılar, yaşlı katılımcılara göre daha az ısırık (2,65'e karşı 2,00), daha az çiğnediler (51,02'ye karşı 34,50), daha az yuttular (2,06'ya karşı 3,39) ve daha hızlı yuttular (49,20'ye karşı 30,14). Cinsiyet açısından, erkekler kadınlara göre daha az ısırık (1.94'e karşı 2.59), daha az çiğneme (40.98'e karşı 45.83) ve daha hızlı yuttular (36.72'ye karşı 41.23).

Sonuç: Katıları Çiğneme ve Yutma Testi, yatak başında yutma güçlüğü çeken hastaları belirlemek ve yutmanın oral fazının etkinliğini değerlendirmek için yararlı olabilecek katı bolus yutmanın hızlı, hassas ve objektif bir ölçüsüdür.

Anahtar kelimeler: değerlendirme, çiğneme, yutma, normatif

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INTRODUCTION

Swallowing is a complex neuromuscular process consisting of four phases: oral preparatory, oral (propulsion), pharyngeal, and esophageal. The entire process of swallowing occurs with volitional and non-volitional sensorimotor functions. The volitional phase consists of two parts: the preparatory phase, where food is accepted into the mouth and manipulated in the oral cavity, and the propulsion phase, where the formulated bolus is transported posteriorly into the pharynx to trigger the swallow. Multiple variables play a role in the efficiency of the oral phase some of which include lingual strength, coordination and range of motion, labial and buccal tone and strength, and dentition[1]. This biomechanical process requires structural and functional integrity of many oral structures including the intrinsic and extrinsic lingual musculature[2,3].

Presbyphagia refers to age-related changes in the swallowing abilities of healthy individuals. A few of the changes in the oropharyngeal phase of swallowing include reduced lingual pressures and endurance, reduced speed, and delayed onset of airway protection[4-8]. Although older healthy adults have been shown to have reduced isometric (i.e., static) tongue pressures compared to younger adults, dysphagia does not typically result from isometric pressure declines alone because swallowing (i.e., dynamic) relies on submaximal lingual pressures[7]. Other issues related to the oral preparatory phase include inadequate bolus formation due to poor dentition[9], periodontal disease, poor-fitting dentures, or xerostomia[10]. Factors such as oral-motor weakness, temporomandibular arthritis, dysarthria, and poor coordination may also impair the oral phases of swallowing in disordered populations[11,12,13].

A number of studies have investigated the effects of age and gender on oropharyngeal swallowing in healthy adults. Robbins et al. performed videofluoroscopy and manometry on 80 healthy adults stratified by gender into four age groups[14]. They found significant effects of age for several parameters of swallowing as well as an effect of gender on upper esophageal sphincter (UES) opening duration. Perlman et al. examined oropharyngeal pressures during swallowing in 40 healthy adults using a solid-state pressure transducer inserted transnasally. Their findings revealed that factors such as age, gender, and bolus type influence the duration of oropharyngeal pressures[15].

Objective non-instrumental measures of the oral preparatory and oral phases of deglutition are few. One recent test, the Test of Masticating and Swallowing Solids (TOMASS), was originally developed for a study with Parkinson's disease patients and provides quantitative measures for the process of chewing and swallowing solid foods[16]. During the TOMASS, participants are asked to ingest a standard cracker and say their name once they are finished swallowing the entire cracker. The number of masticatory cycles, number of swallows, number of bites, and total duration to finish the cracker are the outcome measures recorded.

Huckabee et al. conducted a comprehensive reliability and validity study of the TOMASS. They found high inter-rater and test-retest reliability across days and observational measures were found to be highly correlated with an instrumental measure (i.e., surface electromyography). Another study using surface electromyography (sEMG) also documented a significantly high correlation between measures from the masseter muscles and observation of chewing cycles[16]. In the original study, researchers also collected normative data and identified that the test is sensitive to detecting age and gender-related changes in chewing and swallowing performance[17]. Thus, TOMASS provides researchers and clinicians with objective data on the efficiency and integrity of the oral phase of swallowing and solid food ingestion without the need for any instrumentation.

There are currently no normative data for the TOMASS in Turkish adults. Normative data are important for clinical assessments of the oral phase of swallowing. Clinicians must be able to distinguish among normal age-related changes to swallowing from impairment symptoms such as dysphagia to safeguard against overdiagnosis and unnecessary treatment of the latter. The present study aimed to establish normative data for the TOMASS in healthy Turkish adults stratified by age and gender.

MATERIALS AND METHODS

Participants

The sample size for this prospective study was determined based on a power analysis with alpha at .05 (one-tailed) and statistical power of > 0.80. Participants were 144 adults recruited from the general public for this study and stratified into groups based on gender and age. Inclusionary criteria were a

minimum age of 20 and a score of < 3 on the Turkish version of Eating Assessment Tool-10[18]. Exclusionary criteria were a history of oral or pharyngeal disease, dysphagia, neurological disorder, or gastroenterological problems. There were an equal number of males and females in each 20-year band ranging from 20 to 80 years, and > 80 years (see Table 1). The study was approved by the Human Research Ethics Committee of Ankara Yildirim Beyazit University (approval date: 03/04/2020; approval code: 53) and conducted in accordance with the Helsinki Declaration. All participants gave written informed consent prior to participating.

Table 1. Age, gender, and number of participants

Gender	20-40	40-60	60-80	80+	Subtotal
Male	18	18	18	18	72
Female	18	18	18	18	72

Materials

Because measurements on the TOMASS have been shown to vary based on the type of cracker[17], we chose to use a regional cracker, Torku Tatkrak™, which is commercially available and easily accessible in Turkey. Each cracker weighs 4 grams and is rectangle in shape with dimensions of 4 x 6 cm. A digital stopwatch was used to measure the total time to ingest the cracker. Parameters for the data tracking sheet were translated to Turkish and reviewed by the expert panel of three speech and language pathologists. A back translation was completed by a bilingual clinician. The expert panel once again reviewed the translation and approved the final data collection form.

Procedure

The protocol, application procedures, and scoring were identical to the original study[17] with the exception of the type of cracker. The study took place in Ankara, Turkey. While seated, participants were asked to eat a single of cracker 'as quickly and comfortably as possible' and asked to say their name aloud when finished. Participants were encouraged to refrain from speaking while eating the cracker. The task was considered complete when participants spoke their name out loud upon ingestion of the entire cracker. The number of bites was determined by how many pieces of the cracker the individual placed into their mouth. The number of swallows was based on the movement of the thyroid cartilage as the person ate the cracker. The number of chewing cycles was counted through observation of the mandible and a digital stopwatch was used to document the number of cycles. The time started when the person put the cracker into their mouth (past the bottom lip) and was stopped when the person said their name. All measures (number of bites per cracker, number of chewing cycles, number of swallows, and total time to eat the cracker) were written down by the clinician on a data-tracking sheet.

Statistical analysis

Two-way, fixed-factor multivariate analyses of variance (MANOVAs) were carried out to evaluate the influence of age and gender on all variables. Additionally, normative data were established for participants ingesting the cracker, calculated by age and gender as mean and standard deviation (SD) for the number of bites per cracker, number of chewing cycles and swallows per cracker, as well as total time to ingest the entire cracker. All statistical analyses were carried out using IBM SPSS 21 (SPSS, Chicago, Il, USA) with statistical significance at $p<.05$. For post-hoc analyses, the reported p-values represent application of Bonferroni correction for multiple comparisons with significance at p <0.0125 when appropriate.

RESULTS

Age and gender effects

MANOVA with age (Group 1 M= 29.32), Group 2 M=47.89), Group 3 M= 68.17), Group 4 M= 84.64) and gender (Male, Female) as fixed factors revealed a significant main effect of both variables (Age: F = 7.72, p <.001; Gender: F = 8.67, p <.001). The age and gender interaction was not significant (p = .34). Post-hoc tests of individual variables using a Bonferroni correction (Table 2) revealed a significant age effect for the four parameters (number of bites, number of chews, number of swallows per cracker, and total time to ingest the cracker). Normative data represented by the mean and SDs for the TOMASS during the ingestion of the cracker are displayed in Table 3 with effect sizes for mean differences displayed in Table 4. Normative data are stratified by age and gender.

The effects of age were significant across all of the variables (number of bites, chewing cycles, swallows per cracker, and total time to eat the cracker). Post-

hoc analyses using a Bonferroni correction and evaluation of normative data (Table 3) revealed that youngest participants took fewer bites, chewed less, swallowed less, and swallowed quicker than the older groups of participants. On average, younger participants took fewer bites (2.00 versus 2.65), chewed less (34.50 versus 51.02), swallowed less (2.06 versus 3.39), and swallowed quicker (30.14 versus 49.20) than older participants. These data suggest increased effort and time for biomechanical chewing and swallowing movements associated with advancing age.

The effects of gender were significant across three of the four variables (number of bites, chewing cycles, and total time to eat the cracker). Post-hoc analyses and examination of normative data (Table 3) reveals that male participants took fewer bites, chewed less, and ate the cracker faster than age-equivalent females. On average, males took fewer bites (1.94 versus 2.59), chewed less (40.98 versus 45.83), and swallowed quicker (36.72 versus 41.23) than females. The number of swallows per cracker did not significantly differ between males and females. In summary, these results indicate that age and gender have a significant effect on chewing and swallowing performance in healthy adults.

Table 2. Summary of the statistical output for age and gender effects

	Age Effect		**Gender Effect**	
Measure	F	*p*	F	*p*
No. of bites	6.37	<.001	27.52	<.001
No. of chews	28.36	<.001	13.79	<.001
No. of swallows	15.39	<.001	3.73	.52
Total time	38.20	<.001	10.28	<.05

Table 3. TOMASS normative data consisting of mean and SD by age and gender for Torku's Tatkrak™ cracker

		No. of bites*		**No. of chews***		**No. of swallows***		**Total time***	
Gender	**Age**	Mean	*SD*	Mean	*SD*	Mean	*SD*	Mean	*SD*
Males	20-40	1.83	0.71	32.83	4.98	1.91	0.66	28.45	4.67
	40-60	1.94	0.57	39.06	7.36	2.43	0.72	34.14	6.56
	60-80	1.88	0.75	43.67	5.14	2.66	0/84	38.05	5.86
	80+	2.10	0.64	48.35	4.76	3.15	0.98	46.23	4.29
Females	20-40	2.17	0.82	36.16	8.09	2.20	0.93	31.82	6.91
	40-60	2.10	0.72	44.15	14.05	2.46	0.94	35.29	14.04
	60-80	2.88	0.83	49.33	5.77	3.05	0.72	45.64	8.95
	80+	3.19	0.66	53.68	4.33	3.62	0.80	52.16	4.29

*Per cracker

Table 4. Effect sizes for mean differences for age and gender

	No. of bites	**No. of chews**	**No. of swallows**	**Total time**
Age	0.97	1.42	1.71	3.09
Gender	0.81	0.65	0.36	0.55

DISCUSSION

Our study contributes to the literature on the initial phases of swallowing in healthy aging. Results show age-associated declines in musculoskeletal function in swallowing as indexed by four parameters: number of chewing cycles, number of swallows, number of bites, and total duration to swallow. All four variables differed as a function of age. Similarly, all of the variables differed based on gender with the exception of the number of swallows. The average. In summary, these results indicate that age and gender have a significant effect on chewing and swallowing performance in healthy adults. These results are in concordance with prior research.

The cranial nerves that enable the process of chewing specifically include cranial nerve V (trigeminal),

cranial nerve VII (facial), and cranial nerve XII (hypoglossal). Muscles of mastication include the masseters, temporalis, and pterygoids, the lip and buccal musculature, the orbicularis oris, the buccinator, and the intrinsic and extrinsic lingual muscles. These muscles interact with approximately two dozen pairs of striated pharyngeal and laryngeal muscles[19]. Central or peripheral damage to any of these key components may directly impact an individual's ability to chew and indirectly impair the ensuing pharyngeal phase of swallowing.

Sarcopenia, which refers to loss of muscle mass and strength with advancing age in healthy adults may help explain the findings of this study. Age and gender related reductions in lingual muscle fiber diameter[20] as well as tissue changes and increased amyloid deposits in the blood vessels of the tongue[21] have been previously documented. Age-related morphological changes at the level of the muscle[22, 23] have also been reported. One study investigated the effects of age and gender on tongue strength and endurance during meal-time in 22 healthy adults[24]. While they did not find differences between younger and older subjects on measures of tongue strength, perceived effort, or meal duration, all subjects showed overall evidence of fatigue after the meal. Furthermore, there was a trend toward longer meal times for the older group compared to the younger group. Most importantly, three of the oldest subjects in the study were reported to exhibit signs of dysphagia including a wet voice, throat cleaning, and coughing. The oldest subject in their study chose not to complete the second portion of the meal. Although there is a large body of literature on sarcopenia, most of the research has been conducted in the limb musculature. Thus, more research is needed in this area specifically focusing on oral musculature to determine its consequences for mastication and swallowing changes in healthy adults.

Studies examining sensory perceptual processing in healthy adults indicate sensory changes across the lifespan[25, 26]. Sensory changes may have negative consequences for the initial stages of swallowing as well as social aspects of eating. In a study of 60 healthy adults, the researchers found age-related deterioration of viscosity perception in fluids[27]. They also reported gender effects with males exhibiting a more significant deterioration in sensitivity compared to females. Another study investigated the influence of age on oral sensory skills[28]. They found that healthy adults showed age-related deterioration of two-point discrimination for the lip and cheek, but not for the tongue and palate. The authors concluded that oral sensation remains stable over time, showing only a mild decline in function for those over the age of 80. Aspects of sensory perceptual processing that deteriorate with age and the possible influence on deglutition is an interesting question for future research.

There is also much to be learned about the autonomic and biomechanical nature of the presbyphagic swallow. Future studies should investigate the relationship between age and the production of intraoral fluids from the salivary glands, as well as the mediating effects of dentition on swallowing. It may be the case that declines in saliva production and inadequate dentition associated with increasing age are directly related to oral stage functioning in older adults.

Results of our study have several important implications for clinical research. The normative data we obtained may be used to evaluate the oral preparatory and oral initiation phases of swallowing in disordered groups including those with stroke and neurodegenerative diseases. Stroke patients exhibit impairments of the oral phase of swallowing with some studies reporting greater oral phase impairment compared to the pharyngeal phase[29]. Likewise, patients with neuromuscular diseases such as myasthenia gravis have significant oral stage difficulties in swallowing, putting them at greater risk of penetration and aspiration[30]. Quantifying oral phase efficiency in disordered populations may aid in diagnostic and therapeutic decision-making. To this end, these normative data may serve as a valuable metric for clinical assessments of swallowing in the Turkish population.

There are also some limitations to the present study. The data obtained were on healthy adults and did not include any patient groups. Future studies on patient groups will be helpful for determining the sensitivity and specificity of the test in distinguishing healthy and disordered populations. Normative data on different types of crackers may also provide valuable information in future studies.

In conclusion, TOMASS is a non-instrumental, objective test of solid food ingestion. It provides a quick and easy method for evaluating mastication and swallowing skills that can be implemented during bedside evaluations. Normative data for the TOMASS in healthy Turkish adults are provided in

this study. Investigations of the predictive validity of the TOMASS for detecting oropharyngeal dysphagia would be an important contribution to the literature.

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