ACRM
AMERICAN CONGRESS OF REHABILITATION MEDICINE

Archives of Physical Medicine and Rehabilitation

journal homepage: www.archives-pmr.org

Archives of Physical Medicine and Rehabilitation 2015;96:1785-94

ORIGINAL RESEARCH

Comparison of Maximal Lingual Pressure Generation During Isometric Gross and Fine Sensorimotor Tasks in Healthy Adults

Nicole Rogus-Pulia, PhD,[a,b] Kim Churness, MS,[a,b] Jacqueline Hind, MS,[a,b] Ronald Gangnon, PhD,[c] Kelsey Banaszynski, MS,[a,d] JoAnne Robbins, PhD[a,b]

From the [a]William S. Middleton Memorial Veterans Hospital, Geriatric Research Education and Clinical Center, Madison, WI; [b]Division of Gastroenterology and Hepatology, Department of Medicine, University of Wisconsin School of Medicine and Public Health, Madison, WI; and Departments of [c]Biostatistics and Medical Informatics and Population Health Sciences, and [d]Nutrition, University of Wisconsin, Madison, WI.

Abstract

Objectives: To (1) compare 2 distinct isometric lingual press tasks, fine sensorimotor versus gross sensorimotor, at multiple sensor locations in relation to age and sex; and (2) provide a normative data set using a lingual-strengthening device.

Design: Cohort study.

Setting: University.

Participants: Healthy men and women (N=71; age range, 21−82y) recruited from the community.

Interventions: Participants were stratified by age and sex and divided into 3 age groups. Participants completed, in random order, 2 isometric tasks: (1) fine sensorimotor: tongue press maximally and discreetly against each of 5 sensors; and (2) gross sensorimotor: tongue press maximally against all 5 sensors simultaneously.

Main Outcome Measures: Primary outcome was maximum isometric pressure in hectopascals (hPa). Secondary outcomes were time to reach peak pressure (s) and pressure gradient (hPa/s).

Results: Maximum pressures were significantly lower in those of older age for both fine and gross sensorimotor lingual tasks ($P<.01$), with the front and back sensors showing the greatest decline (35% and 45%, respectively). Pressure differences between tasks ($P=.0012$) resulted in the fine sensorimotor task generating higher pressures at the front sensor for all age groups. However, the gross sensorimotor task generated faster maximum pressures at all sensor locations for all age groups. For both sensorimotor tasks, subjects of older age as a whole generated less steep pressure gradients ($P<.001$).

Conclusions: Age-related decline in tongue strength is greater at the anterior and posterior tongue. Results indicate a simpler gross sensorimotor task may be more beneficial for targeting timing as a biomechanical parameter during therapy, and the fine sensorimotor task may be more beneficial for targeting strength.

Archives of Physical Medicine and Rehabilitation 2015;96:1785-94

Dysphagia affects as many as 15 million Americans,[1] with the prevalence increasing with advancing age. Dysphagia affects 22% of those older than 50 years, and up to 55% of adults in aged-care settings.[2-4] Consequences of oropharyngeal dysphagia may include aspiration pneumonia, malnutrition, dehydration, weight loss, and reduced quality of life. Understanding the biomechanics and kinetics that contribute to dysphagia will allow for improved management and prevention of its negative influence on overall health.

Presented in part to the Dysphagia Research Society, March 6, 2014, Nashville, TN; and the American Speech-Language-Hearing Association, November 15, 2013, Chicago, IL.

Supported by the United States Department of Agriculture (grant no. NRI2007-2234). The views and content expressed in this article are solely the responsibility of the authors and do not necessarily reflect the position, policy, or official views of the Department of Veteran Affairs or the U.S. Government.

This manuscript was prepared at the William S. Middleton Memorial Veteran Affairs Hospital, Madison, WI; Geriatric Research, Education and Clinical Center manuscript #2014-016.

Disclosures: Robbins has received patent licenses or has patent licenses pending from Bracco Diagnostics, Inc, and Swallow Solutions, LLC. Hind reports financial support from Swallow Solutions, LLC, outside the submitted work. The other authors have nothing to disclose.

0003-9993/15/$36 - see front matter © 2015 by the American Congress of Rehabilitation Medicine
http://dx.doi.org/10.1016/j.apmr.2015.04.024

The tongue is the major propulsive driving force in healthy oropharyngeal swallowing. Age-related changes in tongue sensorimotor function decrease bolus propulsion in individuals older than 60 years, which prolongs oral transit time and contributes to dysphagia in the elderly.[5,6] Changes in oral-motor function are due at least in part to sarcopenia.[7] Relative to the oropharyngeal musculature, this diminished tongue muscle mass may lead to reduced tongue strength.

Tongue strength correlates with oral and pharyngeal transit times, as well as the percentage of oral residue,[8] and is a predictor of oral phase swallowing impairment.[9] Following tongue-strengthening protocols, maximum isometric lingual pressures increased in relatively young and older adults.[10-15] Carryover to swallowing function has been observed through increased peak swallowing pressures,[10,12] reduced pharyngeal residue,[12,15] faster oral transit times,[12] decreased penetration/aspiration scale scores[16] (less airway invasion),[12,15] and improved swallow-specific quality of life.[12,13,15,17] While initial findings support the use of muscle-strengthening programs, optimal approaches for building tongue strength remain to be elucidated. Various regions of tongue function have been analyzed relative to pressure generation[6,10,12,18-21]; however, patterns of tongue pressure generation at multiple sensor locations comparing gross and fine sensorimotor lingual isometric tasks have not been examined. Complex biomechanics and kinetics of the tongue are critical for optimizing lingual strength (for intrinsic and extrinsic muscles) and require further study regarding the most effective ways to engage different tongue regions for isometric lingual-strengthening protocols. It remains unknown how sensorimotor task instructions, which may influence cognitive understanding, lingual neuromotor control, and sensorimotor feedback, may affect timing, pressure building, and maximum isometric pressures generated at varying tongue regions.

The purpose of this study was to compare 2 isometric lingual tasks (gross vs fine) in relation to age and sex. This study also sought to provide normative data across the healthy adult life span. Five specific hypotheses were tested: (1) The maximum isometric pressure will be lower in those of older age during both sensorimotor tasks. (2) The time to reach maximum isometric pressure will be lower in those of older age for both sensorimotor tasks. (3) A higher maximum isometric lingual pressure will be generated during the fine sensorimotor task.[22,23] Since the greatest range of forces may be produced by recruiting more motor units,[23] isolated pressure production and motor units at 1 region of the tongue are likely to generate more strength than when activating and diffusing muscle fibers across the tongue (eg, whole tongue press). (4) A faster time to reach maximum isometric pressure occurs during the gross sensorimotor tasks. (5) The pressure gradient becomes less steep in those of older age for both sensorimotor tasks.[18,24-26] Decreased innervation of muscle fibers in human skeletal muscle, particularly type II fast twitch fibers,[26] along with slowed movements[24] and slower swallowing[25] in older adults, suggests that pressure building may be slower.

Methods

Participants

Seventy-one healthy men and women were recruited into 3 sex-matched age groups a priori: group 1 (youngest), group 2 (middle), and group 3 (oldest) (table 1). These groups were sex matched in that the same number of men and women was recruited into each group.

Table 1 Subject demographics

	Age (y)		Sex	
Group No.	Range	Mean	Men	Women
1	21–40	25	12	11
2	41–60	50	12	12
3	61–82	68	12	12

Subjects were recruited through community flyers. Inclusion criteria were (1) age ≥21 years; (2) self-reported normal swallowing; (3) consuming a general diet; and (4) able to provide informed consent. Exclusion criteria were (1) a history of neurologic insult/disease; (2) a history of swallowing problems; (3) the presence of food allergies; and (4) a history of or treatment for head/neck cancer.

Pressure instrumentation and placement

Fine and gross sensorimotor tasks were measured using the Madison Oral Strengthening Therapeutic device.[a] The instrument consists of a mouthpiece connected to a dedicated netbook computer for measuring lingual pressures in hectopascals (hPa). The mouthpiece has 5 air-filled sensors for quantification of pressure individually (single sensor) or simultaneously (multiple sensors) (fig 1). The mouthpiece is 1 size and custom molded by the clinicians to the hard palate, with the anterior sensor at the alveolar ridge. Sensors are equal distance between one another. Given different palatal configurations, the remaining sensors, while still in the areas of left, right, and back of the palate, may be slightly different between subjects, but within subject relative relationships are maintained. Because the mouthpiece is custom molded, intrasubject sensor placement is consistent across all swallows. The sampling rate is 100Hz.

Isometric lingual testing procedure

Subjects completed 2 types of isometric lingual tasks: gross s-motor and fine sensorimotor. The gross sensorimotor task was defined as pressing the whole tongue against all 5 sensors

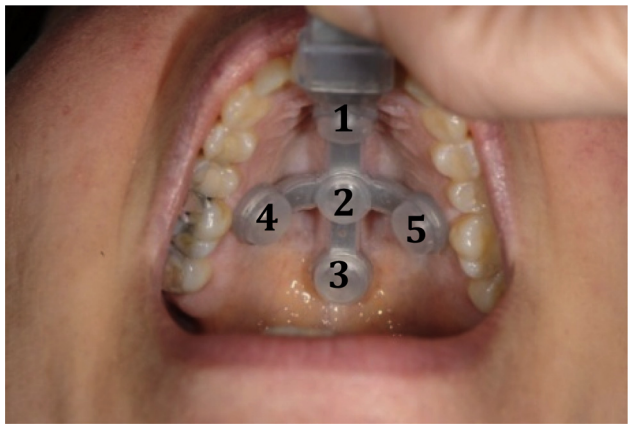

Fig 1 Photograph of Madison Oral Strengthening Therapeutic device custom-fit mouthpiece that consists of 5 pressure sensors: 1, anterior; 2, middle; 3, posterior; 4, right; 5, left.