Original Paper

Folia Phoniatrica et Logopaedica

Folia Phoniatr Logop 2011;63:36–42
DOI: 10.1159/000319737

Variability in Execution of the Chin-Down Maneuver by Healthy Adults

C.M. Steele[a–c] D. Hung[b] E. Sejdić[b, c] T. Chau[b, c] S. Fraser[d]

[a]Toronto Rehabilitation Institute, [b]University of Toronto, [c]Bloorview Kids Rehab, Toronto, Ont., and
[d]St. Joseph's Hospital, Hamilton, Ont., Canada

Key Words
Dysphagia · Swallowing · Rehabilitation · Head posture · Chin-down maneuver

Abstract

Objective: The chin-down maneuver is commonly used in dysphagia management to facilitate greater airway protection. However, the literature suggests that variation in maneuver execution may threaten the effectiveness of the intervention. Our goal was to study variation in chin-down maneuver execution given a uniform instruction. ***Methods:*** Sagittal view digital video recordings were acquired from 408 healthy adults who performed sequences of reiterated water swallows in head-neutral and chin-down positions. Head angle measurements were extracted from the recordings, using markers on goggles worn by 176 participants. ***Results:*** We observed considerable variation in head angle in the head-neutral swallowing task, with a trend to greater flexion in participants over the age of 65. Male participants showed greater variation in head angle than females. Head flexion during the chin-down swallowing tasks averaged 19°, in the range reported to yield clinical benefit in radiographic studies. ***Conclusion:*** We conclude that a clear, uniform instruction is adequate to facilitate execution of the chin-down maneuver to a degree that is likely to be of clinical benefit. The variation in head angle observed in this study warrants further research, particularly regarding the relationship between anatomical cervical spine curvature and head angle influence on swallowing.

Introduction

The chin-down posture is a frequently used compensatory maneuver for dysphagia [1] and head posture is recognized to influence swallowing physiology [2]. However, confusion still exists regarding the precise manner in which the chin-down maneuver should be performed [3]. Clinicians have differing opinions regarding the degree to which head flexion, neck flexion or both are required for the maneuver [3]. Furthermore, the terms chin-down and chin-tuck appear to be used interchangeably by some [4], but denote differences in maneuver execution by others [3]. The purpose of the current study was to investigate execution of the maneuver by healthy participants following a uniform verbal instruction. We wanted to determine the degree to which head angle differed during performance of a series of discrete chin-down swallows of water compared to a series of discrete water swallows performed with the head in a neutral position.

KARGER

Fax +41 61 306 12 34
E-Mail karger@karger.ch
www.karger.com

1021–7762/11/0631–0036$38.00/0

Accessible online at:
www.karger.com/fpl

Catriona M. Steele
Toronto Rehabilitation Institute, 550 University Avenue
Toronto, ON M5G 2A2 (Canada)
Tel. +1 416 597 3422, ext. 7603
E-Mail steele.catriona@torontorehab.on.ca

The chin-down maneuver was first described in a study of 53 patients with dysphagia who underwent radiographic examination of swallowing with the head in resting posture (neutral), a flexed position (chin-down) and an extended position [5]. For the chin-down condition, participants were instructed to 'tilt their heads forwards as far as possible' and swallow. While not explicitly stated, it is presumed that the bolus was already in the mouth at the time of head flexion. In that study, 9 of 18 patients who had impaired laryngeal closure in a head-neutral position showed improved airway protection with a chin-down position. One participant demonstrated worse airway protection with flexion, while the remaining 8 participants showed no change. Ekberg [5] concluded that laryngeal closure and epiglottic deflection were enhanced in a chin-down position. Further, hyomandibular and thyro-hyoid distances were both reduced in the chin-down posture, and the pre-epiglottic fat pad (tissue at the base of the epiglottis, superior to the thyroid) was observed to bulge backwards and partially obliterate the laryngeal opening. No specific comparisons of aspiration rates across positions were reported.

Subsequent research has provided further insights regarding the biomechanical effects of the chin-down posture and the swallowing benefits that may result. Castell et al. [6] explored the manometric effects of the maneuver in a small sample of 9 healthy young adults who swallowed with their chins at 15 and 30° angles relative to the cervical spine, as well as in neutral and extension positions. They reported no appreciable change in manometric measures (peak pharyngeal contraction pressure, upper esophageal sphincter residual pressure, duration of upper esophageal sphincter relaxation, duration of pharyngeal contraction) during head flexion.

Welch et al. [4] explored how head flexion alters the geometry of the pharynx in 30 individuals with dysphagia. Static lateral radiographic images were taken during head-neutral and chin-down positions, and used to compare the relative positions (distances and angles) of the epiglottis, tongue base, anterior laryngeal wall, and laryngeal vestibule. Changes with a chin-down posture included: narrowing of both the epiglottic-pharyngeal wall distance and laryngeal vestibule width, and widening of the epiglottic-laryngeal vestibule angle. These were interpreted to reflect a posterior shift of anterior pharyngeal structures, resulting in narrowing of the pharyngeal lumen and the laryngeal entrance. Statistically significant groupwise mean differences between neutral and chin-down postures in that study were reported as follows:

(1) the angle between the ramus of mandible and the posterior pharyngeal wall lowered to 75 ± 3° in chin-down versus head-neutral (89 ± 1°, $p < 0.0001$);
(2) epiglottic angle (i.e. the angle between the undersurface of epiglottis, near its base, and the anterior laryngeal wall at level of arytenoids) increased to 157 ± 2° in chin-down compared to head-neutral (152 ± 2°, $p = 0.007$);
(3) epiglottic distance (i.e., horizontal distance from the tip of epiglottis straight back to the posterior pharyngeal wall) lowered to 8.1 ± 1.1 mm in the chin-down position versus head-neutral (12.5 ± 1.2 mm, $p < 0.0001$), and
(4) laryngeal vestibule width (i.e., horizontal distance from the tip of arytenoid process straight forward to the anterior laryngeal wall) lowered from 12.8 ± 1.3 mm in head-neutral to 7.8 ± 0.9 mm in chin-down position ($p < 0.0001$).

In a related study, Shanahan et al. [7] compared physiological measures of swallowing safety, timing and efficiency in 30 patients with neurogenic dysphagia who swallowed 1-, 3-, 5- and 10-ml volumes of thin liquid barium in head-neutral and chin-down positions. The posture used for the chin-down task was described as swallowing with the chin 'maximally lowered' and was measured using the same methods as in the study by Welch et al. [4] on representative frames extracted from the videofluoroscopic recordings. Participants were subdivided into two equal groups of those who benefited, or did not benefit, from using the chin-down posture, with benefit defined as a reduction in aspiration. Those who benefited were described as tucking their chins to a greater degree (13.5 ± 1.6° versus 9.2 ± 3.4°) versus a head-neutral measurement, but this difference was not statistically significant. These participants were also shown to achieve a reduction in epiglottic angle (0.4 ± 5.5°), while those who continued to aspirate actually showed an increase in epiglottic angle (18 ± 5.9°). None of the other measurement comparisons showed statistically significant differences between groups.

In a third study from the same research group, Rasley et al. [8] explored benefit from the chin-down posture, in the form of reduced aspiration, in a sample of 165 patients undergoing videofluoroscopy. For patients who demonstrated aspiration on 1 ml and larger volumes of thin liquid barium in a head-neutral position, the chin-down posture eliminated aspiration 71% of the time. For those who demonstrated aspiration on 3 ml and larger volumes of thin liquid barium in head-neutral position, the maneuver was beneficial in 69%. For a smaller number of patients in whom aspiration in head-neutral position was limited to 5-ml and 10-ml volumes of thin liquid barium, the maneuver was successful 57% of the time. Results were equivocal for patients who experienced aspiration only in the context of large-volume cup drinking. Rasley et al. [8] concluded that the benefits of the chin-down position differed, depending on the physiological reason for aspiration. They noted that the maneuver failed to address aspiration attributed to delayed pharyngeal swallow in 18 patients with etiologies of stroke, spinal cord injury or head injury who were judged unable to assume the target posture. By contrast, the maneuver failed to address reduced laryngeal elevation as the mechanism of aspiration in 8 patients with a history of supraglottic laryngectomy. A subsequent study by Logemann et al. [9] focused exclusively on patients with a history of supraglottic laryngectomy or composite resection for oral cancer, and concluded that the chin-down posture, used in isolation without concurrent execution of other compensatory maneuvers (such as the supraglottic swallow or an effortful swallow), was beneficial for reducing aspiration in 5 of 6 patients. Similarly, Lewin et al. [10] showed that the chin-down posture was effective for eliminating aspiration of all items and volumes in 81% of 23 patients undergoing videofluoroscopy after esophagectomy. Most recently, the chin-down posture was one of three interventions evaluated in a randomized study in 711 patients with dementia or Parkinson's disease, known to aspirate thin liquids [11]. In videofluoroscopy, the chin-down posture was shown to successfully eliminate aspiration on subsequent thin liquid swallows in 31% of participants.

Finally, a series of papers by Bülow et al. [12–14] provides insights regarding the effects of the chin-down posture on swallowing in a small sample of 8 healthy adults and a comparator sample of 8 adults with dysphagia attributed to stroke (n = 6) or head and neck cancer (n = 2). In these studies, participants were instructed to 'tuck the chin-downward' during the maneuver. This resulted in reduced laryngo-hyoid and hyoid-mandibular distance measures in all participants. However, weaker pharyngeal contractile pressures were noted in the healthy participants during execution of the maneuver, leading the authors to speculate that the maneuver could be detrimental in patients with weak pharyngeal constrictor muscles. In their patient sample, these authors found no differences in peak intrabolus pressures with the maneuver and noted benefit, in the form of reduced aspiration for 3 of 5 patients who presented with frequent and severe bolus misdirection in a head-neutral position.

In synthesizing the results of these previous studies, several conclusions appear warranted: (1) the instructions for execution of the chin-down maneuver vary across studies and are likely to vary similarly in clinical practice; (2) a chin-down posture alters the geometry of the oropharynx (reduced hyo-mandibular and thyro-hyoid distances and reduced laryngeal width appear to be common findings); (3) there appears to be minimal, if any, impact of the maneuver on swallowing pressures, and (4) the effectiveness of the maneuver for limiting aspiration is equivocal and appears to depend on the mechanism behind aspiration. With respect to this last conclusion, execution of a chin-down maneuver in the presence of poor oral bolus control or delayed pharyngeal swallow does not appear to be beneficial. This suggests that the ideal timing of chin-down maneuver execution needs to be better understood relative to bolus delivery.

The current study is an observational study in which we explored variation in chin-down maneuver execution in healthy adults, given a uniform and simple instruction. Our intent was to document the extent to which patient interpretation of instructions might lead to variation in performance of the maneuver as a further threat to its effectiveness. We hypothesized that healthy adults performing a chin-down maneuver would typically lower their chins by less than 15° versus head-neutral and that substantial variation in head angle would be observed, even in the context of uniform verbal instructions. Our goal was to determine whether closer supervision of maneuver execution might be needed in clinical practice.

Methods

The data for the current investigation were collected as part of a larger research protocol involving the collection of anthropometric and demographic data and swallowing signals captured by video recording and dual-axis accelerometry. Data collection was set up in the exhibit area at a science museum and participants were recruited from the general public. Analysis of the accelerometry data has been reported elsewhere [15].

Participants

Four hundred and eight healthy individuals (ranging in age from 18 to 80) volunteered for participation in this study. Eligibility to participate was confirmed using a short survey of questions exploring swallowing and health history. Individuals who reported a history of neurological conditions, dysphagia, head or neck cancer or tracheotomy were excluded. Before proceeding with data collection, a registered speech-language pathologist completed a brief oral mechanism and swallowing assessment to rule out the presence of overt clinical signs that might suggest the presence of dysphagia [16–18]. This assessment involved evaluation of voice quality, tongue range of motion, maximum phonation time and volitional cough. Participants were asked to report any difficulties that they might commonly experience during the drinking of water, such as coughing [16]. Water swallows were not specifically observed at this stage because they were to be included in subsequent study procedures. Participants who reported or displayed abnormal results on any of these prestudy procedures were excluded from the remainder of the study. Participants who reported awareness of swallowing difficulties were advised to explore these symptoms with their family physician. All participants provided written consent. The research protocol was approved by the research ethics boards of the collaborating hospital-based research institutes and by the science museum.

Data Collection

The methods in this study are similar to those used in other video analyses of sagittal spinal posture [19]. Participants were seated in a chair in front of a vertical reference line displayed on a white screen. The participants wore dark goggles marked with bright yellow dots to allow the extraction of head angle from continuous video recordings taken during swallowing tasks (fig. 1). Digital video recordings were captured using a web-cam at 30 frames per second. Data were collected using a custom LabVIEW program running on a laptop computer and saved for subsequent off-line analysis.

Immediately following experimental setup, each participant was cued to perform a task training set of 3 swallows to familiarize them with the experimental tasks. The experiment then proceeded with the performance of 5 cued saliva swallows with 30-second rests between each swallow. These saliva swallows were not used for the current analysis. The participant was then asked to complete 5 water swallows in head-neutral position (perpendicular to the floor) with brief rests between each swallow. Finally, participants were asked to perform water swallows utilizing a chin-down posture. The specific instructions for the chin-down task were as follows: 'take a small comfortable sip of water, hold the water in your mouth, now tuck your chin so that it touches your chest and so that you can see your knees, then swallow.' This chin-down task was repeated 5 times.

Data Processing

In many of the acquired video recordings, the participant's hair obscured visualization of the bright yellow markers on the goggles. Data with good visualization of the goggle dots allowing the extraction of head angle were available from 176 healthy adults (age: 18–81; 110 males, 66 females). The first frame of each video recording was manually cropped to select the region containing the goggle markers. This region served as the initial template for marker position. The location of the markers in the next frame was found by calculating a two-dimensional cross-correlation between that frame and the reference template. The region of highest correlation was then segmented to determine the coordinates of the three markers. A line was then defined through the upper two markers and the Euclidean dot product was used to measure head angle with respect to the image's vertical coordinate. The template was then updated using the region containing the markers and this process was repeated until all frames of the video were processed.

Fig. 1. A participant wearing goggles with yellow fluorescent markers allowing the extraction of head angle relative to the vertical axis of the image.

Analyses

The image processing algorithm yielded a time series of head angles that required post-processing to remove noise. Data points that fell more than two standard deviations away from the mean were removed and the time series was then filtered with a moving average and median filter to smooth the data and remove impulse noise. Mean head angles for the head-neutral and chin-down water swallows were then calculated as the means of the respective post-processed head angle time series data. Mean maximum chin-down head angle was determined by extracting local extrema from the postprocessed chin-down time series. The resulting data set comprised the following measures for each participant: (a) head-neutral water swallow mean head angle; (b) chin-down water swallow mean head angle, and (c) chin-down water swallow maximum head angle. Group means and standard deviations for these measures were calculated by gender and age category (i.e., <35, 36–50, 51–65 and >65 years of age). Gender differences were first analyzed with a t test using 95% confidence intervals, followed by a Mann-Whitney U test for differences in medians. A general linear model analysis of variance (ANOVA) with between-participant factors of age-group and gender was then performed. Finally, regression analysis was performed using age as a continuous variable to identify any trends that were not revealed through the groupwise ANOVA.

Results

Theoretically, we had no reason to expect a difference between genders in head angle based on previous literature [20]. However, the analysis of the gender-sorted head angle data (table 1) revealed a significant difference for

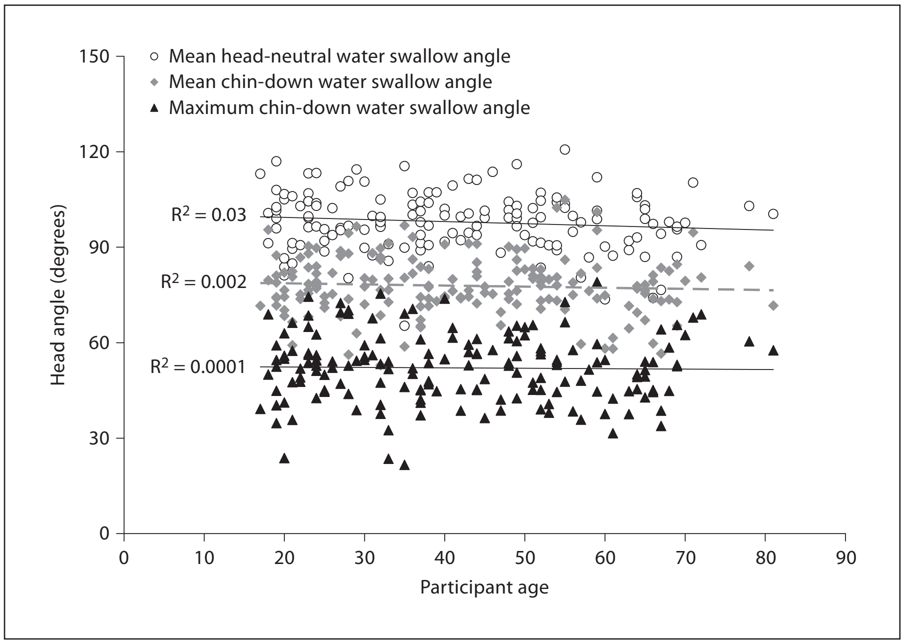

Fig. 2. Scatter plot showing correlations between head angle measures, by task, and participant age.

Table 1. Gender-based differences in extracted head angles

	Overall	Male	Female
Mean head-neutral water swallow head angle	97.4 ± 10.8 (95.7, 99.1)	95.9 ± 11.9 (93.5, 98.2)	100 ± 7.92 (98.1, 102.3)
Mean chin-down water swallow head angle	78.2 ± 9.81 (76.7, 79.7)	77.3 ± 10.9 (75.3, 79.4)	79.7 ± 7.52 (77.8, 81.5)
Maximum chin-down water swallow head angle	52.5 ± 11.1 (50.9, 54.2)	51.6 ± 11.6 (59.4, 53.8)	54.1 ± 10.0 (51.6, 56.5)

Values are mean ± SD followed by 95% confidence intervals.

the mean head-neutral condition ($t = 2.7006$, d.f. = 149, $p = 0.008$, two-tailed), with the male participants exhibiting a greater degree of baseline flexion (i.e., a smaller head angle). Variance between the two gender subgroups was found to be uneven, with the male subgroup displaying greater variance than the female participants. The Mann-Whitney U test revealed a statistically significant difference in group median values (U-female = 3,375, U-male = 2,169, $Z = 2.2443$, $p = 0.025$, two-tailed). Effect size for this difference in the mean head-neutral data was calculated at 0.38 (weak) using the Cohen's d statistic [21]. No gender differences were found for the mean chin-down ($p = 0.10$) and maximum chin-down ($p = 0.13$) measures.

Descriptive statistics for head angle by condition and age-group are shown in table 2. Our analyses failed to find significant differences between age groups in any of the head angle position measurements (mean head-neutral angle: $F(3,142) = 1.5$, $p = 0.22$; mean chin-down angle: $F(3, 163) = 0.37$, $p = 0.77$; maximum chin-down angle: $F(3, 163) = 0.61$, $p = 0.61$). No significant age-group by gender interactions were identified. The regression analysis of head angle for each task, by participant age, further confirmed the absence of any statistically significant trends with respect to head angle and age, as shown in figure 2.

Discussion

The results of this study suggest that healthy individuals flex their necks by approximately 19 degrees (on average) compared to a natural (head-neutral) drinking position, when instructed to perform a chin-down maneuver.

Table 2. Age-group differences in head angles

	Age <35	35≤ age ≤50	51≤ age ≤65	Age >65
Mean head-neutral water swallow head angle	98.7 ± 8.82 (96.4, 101.1)	99.2 ± 9.12 (96.4, 101.9)	96.8 ± 9.42 (93.6, 100.0)	89.1 ± 20.6 (77.2, 101.0)
Mean chin-down water swallow head angle	78.3 ± 8.99 (76.0, 80.5)	79.4 ± 10.7 (76.3, 82.4)	77.4 ± 10.6 (74.0, 80.7)	76.2 ± 9.55 (71.3, 81.2)
Maximum chin-down water swallow head angle	52.8 ± 11.3 (49.9, 55.6)	53.3 ± 12.1 (49.8, 56.7)	49.9 ± 10.0 (46.7, 53.1)	53.9 ± 10.6 (48.5, 59.4)

Values are mean ± SD followed by 95% confidence intervals.

The previous study by Welch [4] suggests that clinical benefit, in the form of aspiration reduction, might be expected with flexion of 13.5 ± 1.6°. Thus, it appears that the instructions used in the present study support execution of the maneuver to a degree that could be expected to yield clinical benefit based on previous literature. However, considerable variation occurred in our participant sample in head angle, both during the head-neutral position and within the chin-down task. On average, head angle varied as much as a further 25° between the mean and maximum head flexion measures in water swallows employing a chin-down posture in this study. This variation raises a number of questions. First, it is clear from these data that participants vary in their execution of the chin-down task, in response to a single, uniform instruction. Such variation was anticipated by our hypotheses and suggests that more specific instructions may be needed in clinical situations to ensure flexion that is sufficient to be likely to yield swallowing benefit. Perhaps more interesting is the recognition from these data that considerable variation exists in head angle, even within a head-neutral swallowing task. One possible contribution to such baseline variation is behavioral variation in habitual posture. Although not statistically significant, it is interesting to note that the oldest participants in our study demonstrated a greater degree of head flexion in their head-neutral position than younger participants. It is tempting to speculate that this might reflect a spontaneous behavioral compensation for possible difficulties with oral bolus control. However, another more likely source of variation in head angle, and a possible explanation for the reduced head angle in our oldest participants, is spinal curvature. To date, we are not aware of any articles in the swallowing literature that explore the benefit of a chin-down posture related to spinal curvature. It seems reasonable to assume that different geometric configurations of the upper airway might result from execution of a chin-down posture in individuals with different classes and degrees of cervical spine curvature (lordosis, straight or kyphosis) [19, 22]. Furthermore, the impact of such geometric changes on bolus flow and propulsion might reasonably be expected to differ based on cervical spine curvature. Finally, the current study did not attempt to investigate any temporal aspects of chin-down maneuver execution. As mentioned in our literature review, discussion of the timing of head flexion relative to bolus presentation in the mouth, or, more saliently, to bolus arrival in the pharynx is lacking in the swallowing literature. Understanding variations in maneuver effect and benefit related to the timing of head flexion will be critical for informing the articulation of clear clinical instructions that will support optimal compensation for swallowing impairment using the chin-down maneuver.

Acknowledgments

The authors are grateful to the Ontario Science Centre Payload Science Program and to Erin Yeates, Sonja Molfenter, Fady Hanna, Rebecca Cliffe, Anna Ammoury, Joon Lee, Kadeen Johns, Julie Chan and Katherine Chow for assistance with study design, data collection and analysis. This research was supported by funding from an Ontario Centres of Excellence Proof of Principle Grant, Panacis Medical, and the Toronto Rehabilitation Institute. The authors acknowledge the support of Toronto Rehabilitation Institute which receives funding under the Provincial Rehabilitation Research Program from the Ministry of Health and Long-Term Care in Ontario. The views expressed do not necessarily reflect those of the Ministry.

References

1 Steele CM, Allen C, Barker J, French R, Buen P, Fedorak A, Irvine Day S, Lapointe J, Lewis L, MacKnight C, McNeil S, Valentine J, Walsh L: Dysphagia service delivery by speech-language pathologists in Canada: results of a national survey. Can J Speech-Lang Pathol Audiol 2007;31:166–177.

2 Burkhead LM: Effect of Jaw and Tongue Position on Suprahyoid Muscle Function during Swallowing; doct diss University of Florida, Gainesville, 2005.

3 Okada S, Saitoh E, Palmer JB, Matsuo K, Yokoyama M, Shigeta R, Baba M: What is the chin-down posture? A questionnaire survey of speech language pathologists in Japan and the United States. Dysphagia 2007;22:204–209.

4 Welch MV, Logemann JA, Rademaker AW, Kahrilas PJ: Changes in pharyngeal dimensions effected by chin tuck. Arch Phys Med Rehabil 1993;74:178–181.

5 Ekberg O: Posture of the head and pharyngeal swallowing. Acta Radiol Diagn 1986;27: 691–696.

6 Castell JA, Castell DO, Schultz AR, Georgeson S: Effect of head position on the dynamics of the upper esophageal sphincter and pharynx. Dysphagia 1993;8:1–6.

7 Shanahan TK, Logemann JA, Rademaker AW, Pauloski BR, Kahrilas PJ: Chin-down posture effect on aspiration in dysphagic patients. Arch Phys Med Rehabil 1993;74:736–739.

8 Rasley A, Logemann JA, Kahrilas PJ, Rademaker AW, Pauloski BR, Dodds WJ: Prevention of barium aspiration during videofluoroscopic swallowing studies: value of change in posture. AJR Am J Roentgenol 1993;160: 1005–1009.

9 Logemann JA, Rademaker AW, Pauloski BR, Kahrilas PJ: Effect of postural change on aspiration in head and neck surgical patients. Otolaryngol Head Neck Surg 1994;110:222–227.

10 Lewin JS, Hebert TM, Putnam JB, DuBrown RA: Experience with the chin tuck maneuver in postesophagectomy aspirators. Dysphagia 2001;16:216–219.

11 Logemann JA, Gensler G, Robbins J, Lindblad AS, Brandt D, Hind JA, Kosek S, Dikeman K, Kazandjian M, Gramigna GD, Lundy D, McGarvey-Toler S, Miller Gardner PJ: A randomized study of three interventions for aspiration of thin liquids in patients with dementia or Parkinson's disease. J Speech Lang Hear Res 2008;51:173–183.

12 Bülow M, Olsson R, Ekberg O: Videomanometric analysis of supraglottic swallow, effortful swallow, and chin tuck in healthy volunteers. Dysphagia 1999;14:67–72.

13 Bülow M, Olsson R, Ekberg O: Videomanometric analysis of supraglottic swallow, effortful swallow, and chin tuck in patients with pharyngeal dysfunction. Dysphagia 2001;16:190–195.

14 Bülow M, Olsson R, Ekberg O: Supraglottic swallow, effortful swallow, and chin tuck did not alter hypopharyngeal intrabolus pressure in patients with pharyngeal dysfunction. Dysphagia 2002;17:197–201.

15 Hanna F, Molfenter SM, Cliffe RE, Chau T, Steele CM: Anthropometric and demographic correlates of dual-axis swallowing accelerometry signal characteristics: a canonical correlation analysis. Dysphagia 2009, E-pub ahead of print. DOI 10.1007/s00455–009–9229–9.

16 Mari F, Matei M, Ceravolo MG, Pisani A, Montesi A, Provinciali L: Predictive value of clinical indices in detecting aspiration in patients with neurological disorders. J Neurol Neurosurg Psychiatry 1997;63:456–460.

17 Logemann JA, Veis S, Colangelo L: A screening procedure for oropharyngeal dysphagia. Dysphagia 1999;14:44–51.

18 Daniels SK, Ballo LA, Mahoney MC, Foundas AL: Clinical predictors of dysphagia and aspiration risk: outcome measures in acute stroke patients. Arch Phys Med Rehabil 2000;81:1030–1033.

19 Kyo YL, Tully EA, Galea MP: Video analysis of sagittal spinal posture in healthy young and older adults. J Manipulative Physiol Ther 2009;32:210–215.

20 Medine A, Saglam S, Uydas NE: Relationship between head posture and hyoid position in adult females and males. J Craniomaxillofac Surg 2006;34:85–92.

21 Kotrlik JW, Williams HA: The incorporation of effect size in information technology, learning, and performance research. Information Technol Learning Performance J 2003;21:1–7.

22 Grob D, Frauenfelder H, Mannion AF: The association between cervical spine curvature and neck pain. Eur Spine J 2007;16:669–678.