Biomechanical analysis of hyolaryngeal displacement: integrative review

Análise biomecânica do deslocamento hiolaríngeo: revisão integrativa

Análisis biomecánico del desplazamiento hyolaryngeal: revisión integradora

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Abstract

Objective: to conduct an integrative review of the literature on quantitative assessment procedures of the hyolaryngeal desplacement in the videofluoroscopy. Methods: Databases Lilacs, Scielo, Medline via Pubmed, Cochrane Library and Web of Science/ISI were used, with the inclusion of 15 studies, published between 2000 and 2014, in the English and Portuguese languages. Results: Most of the researchers used the ImageJ program, considered the fourth cervical vertebra as the point of origin, used coin in the chin of the subject to system calibration, evaluated swallowing of 5 and 10ml of liquid, did not describe the number of evaluated swallowing and used two evaluators in the analysis. The main anatomical points were anterior-upper and anterior-lower regions of hyoid and posterior-upper of the subglottic air column as a reference of the larynx. Conclusion: There is a description of the amplitude variation of hyolaryngeal displacement between genders, age groups, and dysphagia healthy subjects and procedures for analysis of the biomechanics of swallowing.

Keywords: Swallowing; swallowing disorders; biomechanical phenomena; hyoid bone; larynx.

Resumo

Objetivo realizar revisão integrativa da literatura sobre procedimentos de avaliação quantitativa do deslocamento hiolaringeо na videofluoroscopia. Método: Foram utilizadas as bases de dados Lilacs, Scielo, Medline via Pubmed, Biblioteca Cochrane e Web of Science/ISI, com inclusão de 15

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Authors’ contributions: SBB Responsible for the manuscript elaboration. LCCV Responsible for guiding the stages of the manuscript elaboration. MARS Responsible for guiding the stages of the manuscript elaboration.

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Received: 04/04/2016
Accepted: 05/08/2016
Introduction

The swallowing mechanism consists in transporting the bolus from the mouth to the stomach. Oropharyngeal dysphagia is a common symptom in some diseases and its origin can be neurological and/or mechanical. The assessment of dysphagia through more objective methods is essential to determine which interventions are more appropriate for each patient.

Videofluoroscopy is a radiological and dynamic examination, recorded in real time and it is considered the gold standard for the research of the swallowing biomechanics in patients with dysphagia. Its use by Speech Therapy complements the clinical evaluation, as it allows the visualization of all stages of swallowing, as well as its alterations and causes, and it allows testing therapeutic maneuvers, helping in the conduct. The recording of images allows the review of the events without the need of exposure to radiation and the comparison of the function of swallowing between healthy subjects and the ones with dysphagia.

The physiology of swallowing can be analyzed qualitatively and quantitatively by videofluoroscopy. Quantitative analysis comprises the measurement of temporal and/or spatial events. Studies that analyze the displacement of the swallowing structures use programs that allow you to make the measurements through the analysis of each event sequence of the images. For this, four main steps are required: image scanning, identification of reference points and anatomical points of interest, the calculation of the coordinates and the generation of spatial position graphics.

One of the quantitative evaluation of the swallowing by videofluoroscopy includes the analysis of the area maximum pharyngeal constriction and opening and closing of the pharyngoesophageal segment (PES) and/or spatial events. Studies that analyze the displacement of the swallowing structures use programs that allow you to make the measurements through the analysis of each event sequence of the images. For this, four main steps are required: image scanning, identification of reference points and anatomical points of interest, the calculation of the coordinates and the generation of spatial position graphics.
structures involved in swallowing\textsuperscript{13}, but there are other programs used for this purpose.

The different methodologies for the analysis of hyolaryngeal displacement may interfere with the data concerning the biomechanics of swallowing, which may explain the variability of responses found in the literature\textsuperscript{14}. Thus, it becomes necessary to determine more equitable methodologies for the data of scientific research to be comparable. Thus, this review aims to identify which procedures are more used in the literature for the quantitative assessment of hyolaryngeal displacement by videofluoroscopy.

**Methods**

This is an integrative review of the literature on the parameters used for quantitative analysis of hyolaryngeal displacement during swallowing. The following stages were: elaboration of the guiding question, search in the literature and critical analysis\textsuperscript{15}. The guiding question that supported the review was: what are the more used procedures and parameters for biomechanical analysis of hyolaryngeal displacement in adults and/or elderly during swallowing in videofluoroscopy?

The databases used were: Medical Literature Analysis and Retrieval System on-line (Medline), Literatura Latino-Americana e do Caribe em Ciências da Saúde (Lilacs, ‘Latin American and Caribbean Literature in Health Sciences’), Scientific Electronic Library Online (Scielo), Web of Science/ISI and Cochrane Library. The descriptors used were swallowing, biomechanical phenomena, larynx, movement, hyoid bone, swallowing disorders and free terms: biomechanics, displacement, dysphagia, excursion, hiolaring* and videofluoroscopy. Several combinations among the descriptors and among the free terms in English, Spanish and Portuguese were performed.

The literature search produced 661 articles. Articles with full available texts were included, published between the years 2000 and 2014 and that analyzed quantitatively the hyolaryngeal displacement during swallowing in adults and/or elderly, being healthy or with dysphagia. Duplicate articles, the ones that did not use videofluoroscopy and studies of review and treatment, by deficit in the description of the methods of quantitative evaluation, were excluded.

**Results**

Of the 661 that were found, only 15 articles met the inclusion criteria. All studies were found in Medline and five were repeated in the Cochrane Library, three in Lilacs and six in Web of Science/ISI. No study of Scielo was selected, as well as none in Spanish (Figure 1).
The analysis of the publications allowed the identification of two main themes: procedures and parameters of biomechanical evaluation of swallowing and measurements of hyolaryngeal displacement (HLD) in healthy subjects and in the ones with dysphagia. Thus, the results of the HLD were presented in separate charts with the studies that analyzed in healthy subjects and in the ones with dysphagia (Charts 1 and 2).

Procedures and parameters of biomechanical evaluation of hyolaryngeal displacement

Most studies, 13 (86.6%), used only thin liquid for swallowing evaluation with variation of both the analyzed volume and the number of swallows by bolus.

By analyzing the displacement of the hyoid, different programs were mentioned in the studies. Five of those studies (33.3%) used several programs, five of them (33.3%) used ImageJ, three (20%) used MATLAB and two (13.4%) did not describe their use.

In relation to the reference points, nine researches (60%) described the reference applied to the hyoid bone, four (26.7%) in the larynx, twelve (80%) in the point of system origin and 15 (100%) described the calibration. Thus, four studies (44.4%) performed markings on the anterior-superior region of the hyoid, three (33.4%) in the anterior-inferior region and two (22.2%) in different regions. All studies that performed markings on the larynx considered the posterior-superior region of the subglottic air column as the reference for the structure displacement calculations. Regarding the point of origin, five studies (33.4%) considered the fourth cervical vertebra (C4) and three (25%) presented different descriptions. Regarding the calibration of the system, five studies (33.4%) used coin in the chin of the subjects, two (13.4%) considered the third cervical vertebra (C3), two (13.4%) the distance between the second vertebra (C2) and the fourth one (C4), two (13.4%) reported a known length of loop in the chin of the subjects, and the rest (26.4%) used other calibration references.

Among the 15 selected studies, nine (60%) reported the existence of more than one evaluator. Of these, seven (77.7%) had two judges and two (22.3%), four evaluators. Five studies (33.4%) did not report the number of evaluators and one (6.6%) mentioned only intra-evaluator agreement and it may result in less robust conclusions. The intra-evaluator agreement ranged between 0.76 and 0.99 and the inter-evaluator one ranged between 0.60 and 1.0. There is an inter-evaluator agreement variation between 0.26 and 0.84 in the qualitative evaluation of the events of the pharyngeal phase of swallowing16,17.

Hylaryngal displacement measurements in healthy and dysphagic subjects

It is still controversy in the literature the influence of the bolus volume in spatial measures of swallowing. A survey showed that changes in the bolus volume does not exert significant changes in the displacement of the hyoid bone during swallowing18; but some studies showed volume effects in the range of movement of the hyoid bone and the larynx7,8,19. In the figures 2 and 3, hyolaryngeal displacement values between genders, in both healthy and dysphagic subjects described in the studies, are arranged.

As to age, older women had higher amplitude of hyoid and larynx displacement in relation to the young ones7. In contrast, young men showed greater range of movement7. According to the authors, this behavior is due to the fact that women present better muscle reserves during aging and that the increase of hyolaryngeal displacement may occur to compensate the effects of aging in the duration of hyolaryngeal elevation and opening of the PES.

As for HLD values described in different age groups, the hyolaryngeal excursion measures are generally higher among young people in relation to the elderly. Elderly have lower excursion amplitude in relation to young people as there is reduction of the muscle reserve during aging8. A study showed that there is increase of the vertical displacement of hyoid (VDH) with the increase of age. However, the sample was composed mostly by women, a factor that may have influenced the result20.

The anterior displacement of hyoid (AHD) and the larynx anterior displacement (LAD) in healthy men and women were lower than the respective values of vertical displacement7-9. The difference can be explained by the fact that VDH is more related to the closing and protection of airways, with more recruited muscles for the movement, which would justify greater amplitude of vertical movement9.
Biomechanical analysis of hyolaryngeal displacement: integrative review

Chart 1. Procedures and parameters of biomechanical evaluation of swallowing in healthy subjects

<table>
<thead>
<tr>
<th>Reference</th>
<th>Sample (gender and age)</th>
<th>Volume/consistency/number of swallows</th>
<th>Program/calibration</th>
<th>Points of reference/origin</th>
<th>Evaluators and agreement</th>
<th>Hyolaryngeal displacement</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ueda et al, 2013 (Japan) [18]</td>
<td>21 subjects (8M;13W) Mean=26 years</td>
<td>2.5; 5, 10 and 20ml of liquid (without specifying the number of swallows)</td>
<td>Dipp MotionPro Metal ball in C3</td>
<td>Anterior-posterior of hyoid bone Point in tragus (origin)</td>
<td>Absence of agreement and number of evaluators</td>
<td>AHD: 1.55 a 1.59 cm VDH: 1.61 a 1.69 cm</td>
<td>The increase of the bolus volume did not influence in the hyoid displacement.</td>
</tr>
<tr>
<td>Logeman et al, 2000 (USA) [7]</td>
<td>16 men 8 (between 21-29 years) 8 (between 80-94 years)</td>
<td>1 and 10ml of liquid barium (2 swallows)</td>
<td>Interactive Coin in the chin</td>
<td>Anterior-superior hyoid region Posterior-superior region of subglottic air column C4 (origin)</td>
<td>2 evaluators Intra-evaluator: 0.90-0.99 Inter-evaluator: 0.89-0.98</td>
<td>AHD in young: 1.46 cm/elderly: 0.84 cm VDH in young: 2.50 cm/elderly: 1.45 cm</td>
<td>The increase of the volume raised the hyolaryngeal displacement and the displacement was lower among elderly in relation to the young.</td>
</tr>
<tr>
<td>Logeman et al, 2002 (USA) [8]</td>
<td>16 women 8 (between 21-29 years) 8 (between 80-93 years) Data compared with Logman, 2000.</td>
<td>1 and 10ml of liquid barium (2 swallows)</td>
<td>Interactive Coin in the chin</td>
<td>Anterior-superior hyoid region Posterior-superior region of subglottic air column C4 (origin)</td>
<td>2 evaluators Intra-evaluator: 0.90-0.99 Inter-evaluator: 0.89-0.98</td>
<td>AHD in young: 1.01 cm/elderly: 1.03 cm VDH in young: 1.29 cm/elderly: 1.54 cm LAD in young: 0.81 cm/elderly: 0.81 cm LVD in young: 2.18 cm/elderly: 2.71 cm</td>
<td>The increase of the volume raised the hyolaryngeal displacement. In young the displacement is greater in men and in elderly in relation to the young.</td>
</tr>
<tr>
<td>Leonard et al, 2000 (USA) [19]</td>
<td>60 subjects (30M:30W) Between 18-73 years</td>
<td>1,3 and 20ml of liquid (without specifying the number of swallows)</td>
<td>ImageJ Radiopaque disc in the chin</td>
<td>Hyoid bone Vertebral column (origin)</td>
<td>4 evaluators Inter-evaluator: 0.75 to 0.90</td>
<td>HDmax in women: 1.39 to 1.81 cm HDmax in men: 2.0 to 2.47 cm</td>
<td>The increase of the bolus volume raised the hyolaryngeal displacement. Men showed higher amplitude of hyoid elevation.</td>
</tr>
<tr>
<td>Kang et al, 2010 (Korea) [20]</td>
<td>60 subjects (20M:40W) G1(mean): 35.9 years G2(mean): 51.3 years G3(mean): 59.4 years G4(mean): 71 years</td>
<td>2ml of liquid (without specifying the number of swallows)</td>
<td>Matlab Coin in the chin</td>
<td>Posterior-superior margin of hyoid C4 (origin)</td>
<td>Absence of description of the agreement and number of evaluators</td>
<td>AHD: G1) 1.33 cm; G2) 1.27 cm; G3) 1.20 cm G4): 1.33 cm VDH: G1) 0.97 cm; G2) 0.82 cm; G3) 0.85 cm G4) 1.20 cm</td>
<td>There is a raise of hyoid vertical displacement as the age increases.</td>
</tr>
<tr>
<td>Kim et al, 2008 (EUA) [9]</td>
<td>40 subjects (20M:20W) G1: 21 to 51 years G2: 70 to 87 years</td>
<td>2ml of liquid (without specifying the number of swallows)</td>
<td>ImageJ Coin in the chin</td>
<td>Hyoid bone C4 (origin)</td>
<td>2 evaluators Intra-evaluator: 0.88 Inter-evaluator: 0.83</td>
<td>HDmax in young: 1.63 cm to 1.80 cm/elderly: 0.98 a 1.16 cm. AHD in women: 1.48 to 1.59 cm/men: 1.20 to 1.30 cm VDH in women: 1.52 to 1.63 cm/men: 1.50 to 1.53 cm</td>
<td>Young show higher anterior hyoid displacement. There was no significant difference in relation to the genders.</td>
</tr>
</tbody>
</table>

Legend: C3 = third cervical vertebra; C4 = fourth cervical vertebra; AHD = anterior hyoid displacement; VDH = vertical hyoid displacement; HDmax = maximum hyoid displacement; LAD = laryngeal anterior displacement; LVD = laryngeal vertical displacement; G = group; M = men; W = women
### Chart 2. Procedures and parameters of biomechanical evaluation of swallowing in dysphagic subjects (continuation)

<table>
<thead>
<tr>
<th>Reference</th>
<th>Sample (gender and age)</th>
<th>Dysphagia / Base disease</th>
<th>Volume / consistency / number of swallows per bolus</th>
<th>Program / calibration</th>
<th>Points of reference / origin</th>
<th>Evaluators and agreement</th>
<th>Hyolaryngeal displacement</th>
<th>Conclusion</th>
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</thead>
<tbody>
<tr>
<td>Bingjie et al, 2010 (China) [10]</td>
<td>105 subjects (57M; 48W) Mean = 65.2 years 100 control (M) Mean = 62 years</td>
<td>Cerebrum-vascular Accident</td>
<td>1ml of liquid with barium 1ml of liquid with barium 10ml of apple with barium 3 cookies with barium (without specifying the number of swallows)</td>
<td>Anterior-superior region of the hyoid Posterior-superior region of the subglottic air column C4 (origin)</td>
<td>Absence of agreement description and number of evaluators</td>
<td>AHD in the control group: 0.97 to 1.18cm/ Patients who aspirated: 0.82 to 1.03cm Patients who did not aspirate: 0.87 to 1.08cm/ VDH in the control group: 1.21 to 1.45cm/ Patients who aspirated: 0.57 to 1.02cm/ Patients who did not aspirate: 1.01 to 1.25cm</td>
<td>The oral transit time, the pharyngeal transit time, maximum vertical extension of the larynx and the hyoid movement are predictors of aspiration.</td>
<td></td>
</tr>
<tr>
<td>Paik et al, 2008 (Korea) [12]</td>
<td>10 subjects (7W; 3M) Mean = 63 years 9 healthy (2M; 7W) Mean = 60 years</td>
<td>Cerebrum-vascular Myopathy</td>
<td>5ml of liquid with barium (without specifying the number of swallows)</td>
<td>Matlab Coin in the chin</td>
<td>Absence of agreement description and number of evaluators</td>
<td>AHD: control group: 1.5cm/CVA: 1.1cm/ myopathy: 0.4cm VDH: control group: 1.3cm/CVA: 1.2cm/ myopathy: 0.8cm</td>
<td>Movements of the hyoid bone and epiglottis are different according to the etiology of dysphagia, with lower amplitude in subjects with myotonic.</td>
<td></td>
</tr>
<tr>
<td>Leonard et al, 2001 (USA) [21]</td>
<td>18 subjects (12M; 6W) between 18 and 73 years 60 control ones (30M/30W) Between 18 and 73 years</td>
<td>Myotonic muscular dystrophy</td>
<td>20ml of liquid (without specifying the number of swallows)</td>
<td>ImageJ Wire loop in the chin</td>
<td>No description</td>
<td>4 evaluators Inter-evaluator = 0.90</td>
<td>HD max in healthy men: 2.47cm/ sick men: 1.90cm/ healthy women: 1.80cm/ sick women: 1.94cm/ LP max in healthy men: 1.25cm/ sick men: 1.23cm/ healthy women: 1.07cm/ sick women: 1.09cm</td>
<td>The hyoid displacement did not differ between men and women. It only differed between men with myotonia and the ones without the disease.</td>
</tr>
<tr>
<td>Reference</td>
<td>Sample (gender and age)</td>
<td>Dysphagia / Base disease</td>
<td>Volume/ consistency / number of swallows per bolus</td>
<td>Program/ calibration</td>
<td>Points of reference/ origin</td>
<td>Evaluators and agreement</td>
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<td>Wang et al, 2010 (Taiwan) [22]</td>
<td>33 subjects (25M;8W) Mean=55.5 years 10 control ones (7M;3W) Mean=53.9 years</td>
<td>Nasopharyngeal carcinoma</td>
<td>5ml of thin liquid (3 swallows)</td>
<td>Matlab Radiopaque clip recorded on the screen</td>
<td>Anterior-inferior region of hyoid C3(origin)</td>
<td>2 evaluators Intra-evaluator = 0.92-0.98 Interevaluator = 0.71-0.83</td>
<td>AHD in the control group: 1.65cm/ Subjects who aspired: 0.64cm/ Subjects who did not aspired: 0.96cm VDH in the control group: 1.38cm/ Subjects who aspired: 1.01cm/ Subjects who did not aspire: 1.37cm</td>
<td>The hyolaryngeal displacement is reduced in irradiated individuals, and those who aspired showed lower excursion.</td>
</tr>
<tr>
<td>Kendal et al, 2001 (USA) [23]</td>
<td>65 subjects (65 years or more) 83 healthy (40M;43W) G1: 18 to 62 years G2: 67 to 83 years</td>
<td>Dysphagia for various causes</td>
<td>1 to 20ml of liquid barium (without specifying the number of swallows)</td>
<td>ImageJ Wire loop in the chin</td>
<td>No description</td>
<td>Absence of agreement description and number of evaluators</td>
<td>HD&lt;sub&gt;max&lt;/sub&gt; in sick women: 1.62 to 1.91cm/ healthy young women: 1.19 to 1.56cm/ healthy elderly women: 1.63 to 2.07cm/ HD&lt;sub&gt;max&lt;/sub&gt; in sick men: 0.98 to 2.16cm/ healthy young men: 1.77 to 2.27cm/ healthy elderly men: 1.98 to 2.47cm</td>
<td>The greatest displacement of hyoid among some dysphagic subjects may be a compensation to reduce the effects of the reduction of the elevation duration of the structure</td>
</tr>
<tr>
<td>Choi et al, 2011 (Korea) [3]</td>
<td>70 subjects (41M;29W) Mean = 67.8 years</td>
<td>Dysphagia for various causes</td>
<td>5ml of thickened (2 swallows)</td>
<td>No program description Symbol recorded in the jaw</td>
<td>No description</td>
<td>1 evaluator Intra-evaluator=0.90</td>
<td>There was no description of absolute numbers</td>
<td>The hyolaryngeal elevation is a risk factor for aspiration of thickened liquid.</td>
</tr>
<tr>
<td>Molfenter et al, 2014 (Canada) [6]</td>
<td>42 subjects (11M; 31W) M: mean=68 years W: mean=63.5 years</td>
<td>Neurological diseases</td>
<td>Bolus smaller or equal to 5ml (minimum of 2 and maximum of 5 swallows)</td>
<td>No program description Distance between C2-C4</td>
<td>Anterior-inferior extremity of hyoid C4 (origin)</td>
<td>2 evaluators Intra-evaluators=0.76 to 0.99 Inter-evaluators=0.74 to 1.0</td>
<td>There was no description of absolute numbers</td>
<td>There was no evidenced difference in the excursion of the hyoid bone between individuals who aspired and who did not aspired.</td>
</tr>
<tr>
<td>Kim et al, 2010 (Canada) [11]</td>
<td>60 subjects (55M;5W) Mean=67.8 years</td>
<td>Cerebrovascular Accident</td>
<td>5 to 10 ml of thin liquid (2 swallows)</td>
<td>ImageJ C3</td>
<td>Hyoid (rest and maximum displacement) C4 (origin)</td>
<td>2 evaluators Inter-evaluators=0.76 to 0.99 Intra-evaluators=0.90</td>
<td>AHD in subjects who aspired: 0.91 to 1.07cm did not aspired:1.07 to 1.15cm VDH in subjects who aspired :1.39 to 1.89cm did not aspired: 1.49 a 1.60cm</td>
<td>There was no difference in the displacement of the hyoid between those who aspired who did not aspire.</td>
</tr>
<tr>
<td>Steele et al, 2011 (Canada) [24]</td>
<td>28 subjects (13W;15M) W:55 e 77anos M:54 a 70 anos</td>
<td>Dysphagia for various causes</td>
<td>5ml of liquid (3 swallows)</td>
<td>Visual Studio Distance between C2-C4</td>
<td>Anterior-inferior extremity of hyoid C4 (origin)</td>
<td>2 evaluators Inter-evaluators=0.60 (measures of various events of swallow)</td>
<td>There was no description of absolute numbers</td>
<td>Anterior displacement of reduced hyoid is associated with the increase of the risk of penetration and aspiration of residue.</td>
</tr>
</tbody>
</table>

Legend: C3 = third cervical vertebra; C4 = fourth cervical vertebra; AHD = anterior hyoid displacement; HD<sub>max</sub> = maximum hyoid displacement; VDH = vertical hyoid displacement; LAD = laryngeal anterior displacement; LD<sub>max</sub> = maximum larynx displacement; LVD = laryngeal vertical displacement; M = men; W = women
Legend: LAD: Laryngeal anterior displacement; LD<sub>max</sub>: Maximum larynx displacement; LVD: laryngeal vertical displacement; AHD: anterior hyoid displacement; HD<sub>max</sub>: maximum hyoid displacement; VDH: vertical hyoid displacement

Figure 2. Hyolaryngeal displacement between dysphagic and healthy women

Legend: LAD: Laryngeal anterior displacement; LD<sub>max</sub>: Maximum larynx displacement; LVD: laryngeal vertical displacement; AHD: anterior hyoid displacement; HD<sub>max</sub>: maximum hyoid displacement; VDH: vertical hyoid displacement

Figure 3. Hyolaryngeal displacement between dysphagic and healthy men
As to gender, two studies showed greater amplitude of DHL among men\(^8,19\). The largest maximum hyoid displacement measurements (HD\(_{\text{max}}\)) among men could be explained by the larynx position in the neck, and therefore there would be movements of greater amplitude during swallowing for the protection of the airways.

Studies evaluating the biomechanics of swallowing in dysphagic individuals\(^{10,12,21-23}\) showed smaller amplitude of movement of the hyolaryngeal complex in some subjects compared to the healthy ones. Among men, the HD\(_{\text{max}}\) presented lower amplitude among dysphagic individuals when compared to healthy ones. However, HD\(_{\text{max}}\) was higher among some dysphagic women. Some authors have reported the existence of adaptive mechanism of the elevation of the hyoid bone in some individuals with dysphagia to reduce effects of the reduction in the duration of the laryngeal elevation\(^{23}\). In Figure 4, there are HLD measured among dysphagic subjects with aspiration and healthy ones.

![Legend: LAD: Laryngeal anterior displacement; LVD: Laryngeal vertical displacement; AHD: Anterior hyoid displacement; VDH: Vertical hyoid displacement](image)

**Figure 4.** Hyolaryngeal displacement between dysphagic subjects with aspiration and healthy ones

The penetration and aspiration characteristics have also been quantitatively evaluated\(^{3,6,10,11,22,24}\). In most cases, individuals with aspiration show lower amplitude of hyolaryngeal movement in relation to healthy ones. It is noteworthy that some studies did not describe the moment of aspiration and, in addition, there is a volume and consistency variability of the assessed diet, factors that may have favored this overlapping of measures in dysphagic subjects compared to healthy ones.

A study compared the swallowing of subjects after Cerebrovascular Accident (CVA) and healthy ones and demonstrated association between aspiration and the reduction of the maximum vertical extension of the larynx and the hyoid bone\(^{10}\). Other researches have shown that the reduction of the hyolaryngeal excursion is associated with the highest risk of aspiration, including post-swallowing residues\(^{3,22,24}\). However, other studies did not show differences in the displacement of hyoid between subjects who aspirated and who did not aspirate\(^6,11\). The discrepancy among studies may be due to the absence of discrimination of the aspiration moment and therefore the mechanisms involved in the reduction of the airway protection could be related to other causes and not to the pharyngeal stage of swallowing. Thus, some authors suggested studies with analysis of swallowing considering the aspiration moment.
Conclusion

After the review, methodological differences were observed among the studies. However, there is a tendency to use the ImageJ program for the analysis of the measures, coin in the chin as reference of system calibration, fourth cervical vertebra as point of origin and swallowing analysis of thin liquid.

As methodology, hyolaryngeal displacement values were variables between genders, age and healthy and dysphagic subjects. This fact indicates the need for methodological standardization of quantitative investigation of hyolaryngeal displacement to favor the evidence-based practice.

References