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### Correspondence address:

R. Cb. Geraldo Calderaro, 75, bl.2/303,  
Jacarepaguá, Rio de Janeiro (RJ), Brasil,  
CEP: 22770-290.  
E-mail: helenaperrut@hotmail.com

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# Characteristics of sequential swallowing of liquids in young and elderly adults: an integrative review

## *Características da deglutição sequencial de líquidos em adultos e idosos: uma revisão integrativa*

## ABSTRACT

**Purpose:** To perform an integrative review of studies on liquid sequential swallowing, by characterizing the methodology of the studies and the most important findings in young and elderly adults. **Research strategy:** Review of the literature written in English and Portuguese on PubMed, LILACS, SciELO and MEDLINE databases, within the past twenty years, available fully, using the following uniterms: sequential swallowing, swallowing, dysphagia, cup, straw, in various combinations. **Selection criteria:** Research articles with a methodological approach on the characterization of liquid sequential swallowing by young and/or elderly adults, regardless of health condition, excluding studies involving only the esophageal phase. **Data analysis:** The following research indicators were applied: objectives, number and gender of participants; age group; amount of liquid offered; intake instruction; utensil used, methods and main findings. **Results:** 18 studies met the established criteria. The articles were categorized according to the sample characterization and the methodology on volume intake, utensil used and types of exams. Most studies investigated only healthy individuals, with no swallowing complaints. Subjects were given different instructions as to the intake of all the volume: usual manner, continually, as rapidly as possible. The findings about the characterization of sequential swallowing were varied and described in accordance with the objectives of each study. **Conclusion:** It found great variability in the methodology employed to characterize the sequential swallowing. Some findings are not comparable, and sequential swallowing is not studied in most swallowing protocols, without consensus on the influence of the utensil.

## RESUMO

**Objetivo:** Realizar revisão integrativa de estudos sobre deglutição sequencial de líquidos, caracterizando o método e os principais achados em adultos e idosos. **Estratégia de pesquisa:** Foi realizado levantamento na literatura internacional, publicada nos idiomas Inglês ou Português, utilizando-se base de dados PubMed, LILACS, SciELO, MEDLINE, dos últimos 20 anos, cujos artigos estavam disponíveis na íntegra. Foram utilizadas as seguintes palavras, em combinações variadas: deglutição sequencial, deglutição, disfagia, copo e canudo. **Critérios de seleção:** Foram incluídos artigos de pesquisa com abordagem metodológica referente à caracterização da deglutição sequencial de líquidos em sujeitos adultos e/ou idosos, independentemente de patologia envolvida. Excluíram-se os estudos que englobavam apenas a fase esofágica. **Análise dos dados:** Foram considerados indicadores da pesquisa: objetivos, número e gênero dos participantes; faixa etária; quantidade de líquido ofertado; instrução para ingestão; utensílio e métodos utilizados; principais resultados. **Resultados:** Dezoito estudos contemplaram os critérios propostos. Os artigos foram tabulados quanto à caracterização da amostra e à metodologia (volume ofertado, utensílio utilizado e tipos de exames). A maioria dos artigos envolveu apenas indivíduos saudáveis e sem queixas de deglutição. Houve diferentes tipos de instrução para deglutir todo o volume: maneira habitual; continuamente; o mais rápido possível. Os achados referentes às caracterizações da deglutição sequencial foram variados e descritos de acordo com objetivos de cada estudo. **Conclusão:** Constata-se grande variabilidade na metodologia empregada para caracterização da deglutição sequencial. Alguns achados não são comparáveis entre si, sendo que a deglutição sequencial ainda não faz parte da maioria dos protocolos de avaliação da deglutição. Não há consenso sobre a influência do utensílio.

Study conducted at the Graduate Program in Speech-Language Pathology and Audiology, Universidade Veiga de Almeida – UVA – Rio de Janeiro (RJ), Brazil.

(1) Graduate Program (Professional Master's degree) in Speech-Language Pathology and Audiology, Universidade Veiga de Almeida – UVA – Rio de Janeiro (RJ), Brazil.

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## INTRODUCTION

Liquids swallowing type varies according to volume offered and can be categorized as either single or sequential swallowing. Single or isolated swallowing occurs when a small volume is swallowed in one single intake. Still, the same amount of liquid can be ingested in multiple swallows especially by dysphagic individuals<sup>(1)</sup>. This is widely reported in both clinical and instrumental swallowing evaluation protocols<sup>(1-3)</sup>.

Sequential swallowing, also known as continuous<sup>(4)</sup> or consecutive<sup>(5)</sup> swallowing, is the multiple and consecutive intake of a large bolus volume<sup>(6,7)</sup>, with or without pauses, with interruptions of breathing, as described in an earlier study<sup>(8)</sup>. Evaluation of sequential swallowing provides the clinician with information on the bolus flow, which is relevant to the typical behavior of intake carried out in a radiological environment structured and controlled<sup>(9)</sup>. Such evaluation allows a more accurate decision making when establishing parameters for oral bolus intake.

Sequential swallowing analysis has been increasing in focus due to its similarity to the natural type swallowing for liquids<sup>(9,10)</sup>, by which the subject controls the intake amount<sup>(7)</sup>, and for showing patterns which differs from isolated swallowing<sup>(11)</sup>. In addition to that, studies show that it takes five to seven swallows per bolus type in order to achieve a reliability degree for measuring the pharyngeal phase of swallowing<sup>(12)</sup>.

Researches show that the utensil and size of cup have an influence on the intake volume<sup>(13)</sup>; therefore, the utensils used in different studies must also be taken into account.

Greater volumes of liquid have been used mainly in screening clinical trials for risk of swallowing dysfunction<sup>(14)</sup>, usually performed by other health-care professional, without standardization of volume and type of swallowing of liquids<sup>(6,15)</sup>.

For a better understanding and identification of the main characteristics of sequential swallowing, it is necessary to collect and analyze studies about the theme in order to search for evidence in the literature.

## OBJECTIVE

To perform an integrative review of the scientific articles about sequential swallowing of liquids published in the past two decades, in order to characterize the method for data collection and the main findings on this type of swallowing in adult and elderly individuals, regardless of previous swallowing complaints.

## RESEARCH STRATEGY

The methodology consisted of an integrative review of the literature, based on the following steps<sup>(16)</sup>: identifying the problem and setting up the guiding question —How can sequential swallowing of liquids be characterized in adult and elderly individuals? — to establish keywords as well as criteria for the inclusion/exclusion of articles; selecting the articles; defining information and data to be collected from the selected articles, such as objectives, methodology and main findings.

This study used articles published in either national or

international journals, written in Portuguese or in English, selected from the following data bases: PubMed, LILACS, SciELO, and MEDLINE. The articles should be available in full. Research period ranged from 1991 to 2011. The following uniterms were used: “sequential swallowing”, “deglutition”, “dysphagia”, “cup”, “straw” (and their equivalent in Portuguese — “*deglutição sequencial*”, “*deglutição*”, “*disfagia*”, “*copo*”, “*canudo*”), in various combinations.

The references cited in the selected articles were checked in order to search for any studies that might have not been shown in the first search.

Based on those research strategies, 24 articles were found and later analyzed for the selection criteria described in the next subsection.

## SELECTION CRITERIA

The selection included articles referring to sequential swallowing of liquids, with a sample of adult and/or elderly subjects, with or without any pathology, as our aim was to characterize sequential swallowing in this age group. Although the inclusion of studies comprising unhealthy subjects brings a greater number of variables to our study, we decided to keep them, due to the restricted amount of studies focusing on sequential swallowing.

Later, six other articles were excluded for not meeting the scope of this integrative review: studies whose methodology did not openly include sequential swallowing<sup>(17)</sup>, even if they report the intake of greater volumes of liquid; studies that used sequential swallowing as a screening method carried out by either a speech-language pathologist or other health-care professionals<sup>(8,14,18-20)</sup>.

Other disqualified articles included those whose sampling consisted of children only; those involving exclusively the esophageal phase of swallowing; and those containing sequential swallowing of pasty or solid foods only. Fragments that did not contain a reference allowing access to the study in full or written in any language other than Portuguese or English were also excluded from this review.

## DATA ANALYSIS

A descriptive data analysis was performed in two phases. At the outset, the following data were taken into account: research objectives; number of participants, their gender and age group; amount of liquid and food intake; intake instruction; utensil; swallowing assessment method; and main findings.

Then, the studies were grouped and analyzed according to the findings on the oral and pharyngeal phases of swallowing.

The choice of the abovementioned analysis variables was grounded on the possibility of gathering data about the characterization of sequential swallowing, and on the due verification of such studies regarding the characterization of the studied sample.

## RESULTS

After applying the inclusion and exclusion criteria, 18

studies, all of them in English, were selected.

The characterization of the sample and the gathering by age group and gender are presented in Chart 1.

Three of the 18 studies analyzed in this review, were carried out by the same group of researchers<sup>(4,21,22)</sup>, considered elderly all individuals above 50 years.

The number of participants in the 18 studies considered for this review ranged from five to 345, with average of 40.6 participants, and median of 17.5 participants, which is more adequate to show participants distribution.

The methodology employed in the studies analyzed – the

volume offered, the utensil used and types of tests performed – are shown in Chart 2. The studies were compiled chronologically, aiming at showing the evolution of the study of sequential swallowing along the years. The number next to the name of the author, in the first column, corresponds to that in which the articles are presented in the References.

As to health and swallowing complaints, 83.3% (n=15) of studies concentrated exclusively on healthy individuals and without swallowing complaints; 16.7% (n=3) studied both healthy individuals and individuals with swallowing complaints.

**Chart 1.** Characterization of sample according to separation by age group and gender

	Variables separated split		Variables not separated		One variable only	
	Total studies	Cited studies*	Total studies	Cited studies*	Total studies	Cited studies*
Age (adults and elderly)	6	4; 11; 21; 22; 32; 33	3	9; 12; 26	9	5; 23; 24; 25; 27; 28; 29; 30; 31
Gender	14	4; 21; 22; 23; 24; 25; 26; 27; 28; 29; 30; 31; 32; 33	2	9; 12	2	5; 11

\* As presented in the Reference section

**Chart 2.** Methodology of the analyzed studies – here presented in chronological order - as to volume offered, type of utensil used and tests performed

Authors	Volume and utensil used	Tests performed
Lazarus et al. <sup>(12)</sup>	1, 3 and 5 ml liquid – 4 swallows each, and 1 ml pasty – 3 swallows	Videofluoroscopic swallowing (VFS)
Martin et al. <sup>(24)</sup>	3, 10, 20 ml (syringe) + 100 ml (straw)	Respiratory plethysmography + Surface electromyography (sEMG) + Fiberoptic endoscopic evaluation of swallowing (FEES)
Nilsson et al. <sup>(32)</sup>	200 ml (straw)	Doppler system; solid state pressure detector; piezo-electric movement sensor; and thermodetector of respiration
Nilsson et al. <sup>(33)</sup>	200 ml (straw)	Doppler system; solid state pressure detector; piezo-electric movement sensor; and thermodetector of respiration
Preiksaitis & Mills <sup>(29)</sup>	5 and 20 ml (syringe) 200 ml (cup and straw) (2x)	Plethysmography + sEMG + microphone
Dua et al. <sup>(27)</sup>	Solid and liquid – fast-food meal (G1) Small amount of liquid and solid, with barium (G2)	FEES + Respiratory plethysmography+ sEMG (G1) VFS + FEES + sEMG (G2)
Chi-Fishman et al. <sup>(23)</sup>	5, 30 (syringe) and 200 ml (cup) (2x)	Electropalatography and Ultrasound
Chi-Fishman & Sonies <sup>(28)</sup>	5, 10 (syringe) and 150 ml (cup) (2x)	VFS + sEMG
Daniels & Foundas <sup>(5)</sup>	300 ml (straw) in 10 sec (2x)	VFS
Hirst et al. <sup>(30)</sup>	10 x 5 ml; 20 ml 100 ml (cup and straw)	Pharyngoesophageal manometry, pulse oximetry and spirometry
Steele & Van Lieshout <sup>(4)</sup>	Trials with 8 sequential swallows with 3 different liquid consistencies (cup)	Electromagnetic articulography
Daniels et al. <sup>(11)</sup>	300 ml (straw) in 10 sec (2x)	VFS
Dozier et al. <sup>(26)</sup>	50 ml (cup)	VFS + Nasal flow meter
Steele & Van Lieshout <sup>(22)</sup>	Comparison between single swallows and sequential swallows (cup)	Electromagnetic articulography
Murguía et al. <sup>(9)</sup>	100 ml (cup)	VFS
Steele & Van Lieshout <sup>(21)</sup>	6 sips of each type, without volume control (cup)	Electromagnetic articulography
Tsushima et al. <sup>(25)</sup>	200 ml (straw)	VFS
Lederle et al. <sup>(31)</sup>	20 ml, 88.7 ml and 177.4 ml (3 trials with each volume) (straw)	Respiratory magnetometer; sEMG; pulse oximetry

As to command to swallow the whole volume, the studies can be sorted in three large groups: in 39% (n=7) participants were oriented to swallow the volume in the usual manner; in 27.8% (n=5) participants were oriented to swallow continuously, without pauses; in 16.7% (n=3) participants were asked to swallow as rapidly as possible. Researchers of one study (5.5%) asked participants to swallow continuously or in the usual manner; in another study (5.5%), participants were asked to swallow continuously and rapidly; and a further study (5.5%) did not report giving any swallowing instructions.

As regards the characterization of sequential swallowing, results are varied and described according to the objectives outlined by each study. In order to allow comparisons between studies, they were grouped according to those findings.

One study<sup>(23)</sup> focused on changes in the tongue for single or sequential swallowing in healthy adults. The authors concluded that the tongue has a single movement pattern; still, it uses shorter and overlapped movements of propulsion in sequential swallowing, during continuous intake of 200 ml of water from the rim of the cup. Yet another study<sup>(21)</sup> that compared healthy adult and elderly individuals reported a longer duration of the tongue movement in this type of swallowing with ageing.

Two other studies<sup>(4,22)</sup> on tongue movement in sequential swallowing stated that, when subjects perform this type of swallowing, tongue movements vary more with ageing<sup>(4)</sup> and there is a stable coordination between the distinct segments of the tongue and the jaw; reduced variability of tongue and jaw movements; and overlapped tongue movements<sup>(22)</sup>. Also, a more varied number of cycles of vertical movements of the tongue when swallowing was reported, even for younger elderly individuals<sup>(4)</sup>.

The movements of the hyolaryngeal complex in sequential swallowing were described in numerous studies<sup>(5,9,11,24,25)</sup>. One of them<sup>(24)</sup> reported elevation of the larynx and closure of the laryngeal vestibule in most individuals. Another study<sup>(5)</sup> described three patterns of movement of the hyolaryngeal complex: lowering of the hyolaryngeal complex and opening of the laryngeal vestibule at each swallow in 53% individuals; maintenance of both the closure of the laryngeal vestibule and the elevation of the hyolaryngeal complex after each swallowing act in 27% subjects; and finally a mixed type in 20% individuals, who alternate between opening and closure of the laryngeal vestibule during the sequence of swallows from the straw. Other studies<sup>(9,11,25)</sup> also observed the three aforementioned types of movement with the straw and/or cup, only with different percentages.

Still regarding the larynx movement, another group of researchers<sup>(26)</sup> found two essential patterns of larynx movement, without any statistically significant difference as to age (adult or elderly individuals) and gender: 67.1% participants showed a lowering of the hyolaryngeal complex and opening of the laryngeal vestibule at each swallowing event, and 31.4% had a mixed type (interchangeable opening and closing after each swallowing act). A comparison between the abovementioned study<sup>(26)</sup>, with n=70, and a previous one<sup>(5)</sup>, with n=15, one may explain the differences in laryngeal movement patterns, as the aforementioned study<sup>(26)</sup> does not employ straw as a utensil,

which might influence the findings.

One study<sup>(25)</sup> assessed the relationship between hyoid movement trajectory patterns, swallowing types based on laryngeal movement and laryngeal penetration during sequential swallowing with straw. A higher degree of penetration was noticed when there was a combination of the maintenance of the laryngeal closure with the elevation of the hyolaryngeal complex after each swallow, together with a movement pattern in which the hyoid moves towards the anterosuperior direction after the onset of swallow, without any movements beyond the mandibular plane.

Another study<sup>(9)</sup> verified whether the movement of the hyolaryngeal complex and bolus location in patients with acute stroke, without significant dysphagia, and in healthy adults affects the safety of sequential swallowing. The presence of partial elevation of the hyolaryngeal complex in healthy and post-stroke adults during the sequential swallowing of 100 ml liquid was significant. In both groups, there was an agreement as to the increase of lower-airway invasion during sequential swallowing when compared to single swallows, but neither parameter affected swallowing safety. The study at issue also observed that the laryngeal closure during sequential swallowing is influenced by both the utensil and the orientation as to the intake method, which is not true for isolated swallows.

Concerning bolus location before sequential swallowing, one study<sup>(27)</sup> noted that the entry of food into the pharynx is a common event during a meal at normal speed in healthy adults, with accumulation in the valleculae before swallowing is initiated. Such entry was seen in 76% swallows of solid boluses and in 60% swallows of liquid boluses (in this study, formed by chewing gum, not by swallowing of liquid during a meal). The entry of bolus into the pharynx was associated with brief adduction of the vocal folds in both cases. The researchers noticed that trajectory of the liquid bolus is different from that of the solid bolus, as it splits around the larynx and rejoin in the hypopharynx.

Another study<sup>(28)</sup> also found liquid accumulation in the pharynx before swallowing in healthy adults. The authors challenge the widespread concept of delay in the pharyngeal transit time, since pharyngeal transit time is slower in sequential swallowing, when compared with single swallowing, merely because the bolus is located at the hypopharynx before the offset of the pharyngeal response. Correspondingly, another study<sup>(5)</sup> states that the hypopharynx is a crucial trigger point to elicit pharyngeal swallow in sequential swallowing of liquid from the straw, in young adults, differently from studies with isolated swallows, in which pharyngeal swallow takes place when the bolus hits the anterior faucial arches. When comparing healthy adult and elderly individuals, a study<sup>(11)</sup> did not find any difference with ageing, and bolus location was more common under the vallecula than at the same level of above it.

Concerning airway invasion in sequential swallowing, 30% healthy adults showed minor episodes of laryngeal penetration, with successful ejection of the content, what is considered normal behavior in this type of swallowing, as stated by one of the studies<sup>(28)</sup>. Another study<sup>(11)</sup> noticed that a significant number of elderly individuals show some degree of airway



invasion, and concluded that ageing, especially after 70 years, interferes with the ability both to keep the airways protected and to proceed to the supraglottic clearance.

As regards swallowing apnea, one of the first studies<sup>(12)</sup> within the span used in this review compared both healthy and post-stroke adult and elderly subjects. Researchers observed that, as bolus volume increases, also increases the duration of laryngeal closure and cricopharyngeal opening, as decreases the tongue base contact<sup>(12)</sup>.

Another group of researchers<sup>(24)</sup> claims to be the first to study swallowing apnea and its associated respiratory phase in healthy adults, instrumentally, with standardized volumes of water and with water in the cup swallowed from a straw (100 ml). No significant difference in the apnea duration was observed for the three standardized volumes; however, when water was offered from the straw, swallowing apnea lasted longer. The authors emphasize that swallowing apnea is usually related to the expiratory phase of respiration, but the use of a straw interferes with this pattern, and some individuals inhale after deglutition. They also point that, when swallowing water from a straw, most individuals perform multiple swallows continuously, i.e., they sustain swallowing apnea. According to the authors, individuals with respiratory diseases are exposed to the risk of aspiration when trying to swallow liquid from a straw by using such multiple-swallow pattern.

Another study<sup>(26)</sup> reported high inspiration rates and opening of the laryngeal vestibule after sequential swallowing of liquid from the cup, which does not happen when swallowing a small volume of liquid. As stated by the authors, the higher inspiration percentage found after swallowing suggests that sequential swallowing from the rim of the cup may put subjects at higher risk for aspiration than single swallows, in case they have any swallowing disorder. Such a high inspiration rate after sequential swallowing was also observed in another study<sup>(29)</sup>, both from the rim of the cup and from the straw. One research comparing cup and straw<sup>(30)</sup> found higher inspiration rates only after swallowing from the straw. Another study<sup>(31)</sup> states that the straw increases the frequency of inspirations before sequential swallowing for demanding lower air pressure in the oral cavity, which can not only elicit inspiration, but also cause respiratory distress in healthy adults.

Two studies carried out by the same group of researchers<sup>(32,33)</sup> evaluated a forced swallow of 200 ml from the straw. The first study<sup>(32)</sup>, with a smaller number of participants, reported that the bolus volume and the suction pressure decrease in elderly individuals with dysphagia; the last one<sup>(33)</sup>, on the other hand, noticed that the elderly population present a high frequency of multiple swallows and higher inspiration frequency after forced swallow from the straw.

## CONCLUSION

The studies of sequential swallowing have gained ground in the past few years. Yet, it is not included in most swallowing evaluation protocols.

The main findings regarding sequential swallowing in adult and elderly individuals were as follows: variability in

hyolaryngeal complex closure; higher inspiration rate after swallowing; bolus entry in the pharynx, with or without residues in the valleculae before swallowing; presence of laryngeal penetration, to some degree; longer duration of swallowing apnea; and overlap of tongue movements.

As to volume offered, intake instructions or tests performed for sequential swallowing evaluation, no standardization was found. Thus, further studies are required for a wider understanding of the characteristics of sequential swallowing in elderly and dysphagic populations.

Some findings are not comparable to one another, due to both the variable number of participants and the use of different utensils. This review did not find any consensus regarding the influence of the utensil in sequential swallowing.

As most studies were carried out with normal subjects, it is difficult to extrapolate their findings to subjects with swallowing complaints.

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