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Original Article

Oral diadochokinesis and masticatory function in healthy elderly

Diadococinesia oral e função mastigatória em idosos saudáveis

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ABSTRACT

Purpose: To relate the findings of oral diadochokinesis (DDK) and masticatory function in healthy elderly. **Methods:** Analysis of medical records and images files of 35 healthy elderly subjects aged 60 to 74 years. The masticatory type and other behaviors associated with mastication of bread (1cm thick), the analysis of food seizure, bolus formation and measurement of chewing time, using a timer, were considered. For DDK assessment, the syllabic emissions "pa", "ta", "ka" and the tri-syllable "pataka", as to the parameters automatically provided by the Motor Speech Profile Advanced program *(*KayPentax®), were analyzed. Relevant statistics was performed for the correlation between the qualitative aspects of masticatory function and DDK. **Results:** The statistical analysis showed a correlation between the chewing time and the parameters coefficient of peak intensity variation of syllable ''ta'' and disturbance time of syllable "ka'', indicating DDK instability. No correlation with the data of oral DDK was seen for the masticatory type, seizure and bolus formation. **Conclusion:** Oral DDK correlated with the chewing time in healthy elderly, showing that the higher the instability in the repetition of movements of the tip and the back of the tongue, during articulatory production, the longer the time required to prepare the food for swallowing.

Keywords: Aging; Health of the elderly; Mastication; Evaluation; Speech articulation tests

RESUMO

Objetivo: Relacionar os achados da diadococinesia (DDC) oral com a função mastigatória em idosos saudáveis. **Métodos:** Análise de prontuários e arquivos de imagens de 35 idosos saudáveis, entre 60 e 74 anos de idade. Considerou-se o tipo mastigatório e outros comportamentos associados à mastigação de uma fatia de pão francês de 1cm de espessura, análise da apreensão do alimento, formação do bolo alimentar e mensuração do tempo de mastigação, utilizando cronômetro. Para avaliação da DDC, foram analisadas as emissões silábicas "pa", "ta", "ka" e a trissílaba "pataka", quanto aos parâmetros fornecidos automaticamente pelo programa *Motor Speech Profile Advanced* - KayPentax®. Para correlação entre os aspectos qualitativos da função mastigatória e a DDC, foi realizada estatística pertinente. **Resultados:** A análise estatística demonstrou correlação entre o tempo mastigatório e os parâmetros coeficiente de variação do pico da intensidade da sílaba ''ta'' e perturbações do período da sílaba ''ka'', indicando instabilidade da DDC. Para o tipo mastigatório, apreensão e formação do bolo alimentar não houve correlação com os dados da DDC oral. **Conclusão:** A DDC oral correlacionou-se com o tempo mastigatório em idosos saudáveis, evidenciando que, quanto maior a instabilidade na repetição dos movimentos de ponta e dorso de língua durante a produção articulatória, maior o tempo necessário para a preparação do alimento para a deglutição.

Descritores: Envelhecimento; Saúde do idoso; Mastigação; Avaliação; Testes de articulação da fala

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INTRODUCTION

During the aging process, changes in the stomatognathic, respiratory, digestive and phonation systems that can influence the performance of speech, chewing and swallowing, are observed. With respect to the oral cavity, periodontal problems, tooth loss, use of prostheses, atrophy of masticatory muscles, decrease in saliva and taste(1), as well as change in the oral sensitivity(2), are described.

The loss of teeth can influence one´s ability to intake various foods(3) and may also be associated with deficit in the activity of muscles involved in chewing and swallowing functions, as well as affect the quality of life of the elderly(4). Different oral health conditions in the elderly (edentulous, partially edentulous, using removable dentures) result in reduced bite force, with no impact on their chewing ability(2). According to the literature, chewing in users of removable prostheses is characterized by changes in food cutting, chewing type and labial function(5). On the other hand, implant supported prostheses decrease the difficulty in chewing(6), improve psychological conditions, the masticatory function, aesthetics(7), the bite force and chewing efficiency(8) in healthy elderly.

By assessing the relationships between oral motor functions of language and lips in the elderly and investigating the effects of these factors on their chewing performance(9), the authors concluded that the tongue can compensate for the lack of teeth in the chewing performance of individuals who have lost their natural teeth, highlighting the importance of tongue function in chewing. In a study which relates the use of dental prostheses to oral motor control, the authors(10) found that the tongue motor skills in dentate elderly users of dentures were lower than those of dentate adults, the tongue motor skill and masticatory performance in complete denture users correlating with age and the appropriate use of the prosthesis, with no influence on the movement of the tongue.

The neuromotor components present in the oral structures, related to the production of sounds, can be assessed by diadochokinesia (DDK), thereby providing data on the patient´s neuromotor integration(11). The assessment of oral DDK comprises phono-articulatory tests, able to assess the function of lips and tongue, by using the repetition of syllables(12).

The oral diadochokinetic performance can be influenced by age(13,14) and gender(15), as well as by the instability of dental prostheses(16), probably owing to the aging process of muscle groups involved in the DDK tests.

As evidenced, aging, loss of teeth and oral rehabilitation influence the masticatory function as well as the results of the assessment of oral diadochokinesia. Therefore, it is expected that the knowledge on oral motor coordination when related to masticatory function, can contribute to the diagnosis and speech therapy and dental treatment, especially in cases of prosthetic oral rehabilitation in the elderly, thus increasing the degree of satisfaction in relation to the services provided.

Thereby, this study aimed at verifying if the findings of the oral diadochokinesia present relationship with the chewing function in healthy elderly.

METHODS

This paper was part of the research project "Voice, Speech and Orofacial Functions of Elderly Undergoing Different Oral Prosthetic Rehabilitation Strategies", approved by the Research Ethics Committee of the Bauru School of Dentistry, *Universidade de São Paulo* (USP) under process No. 111/2006. It was conducted according to the express consent of those involved, who signed the Free and Clarified Consent Term, being clearly informed about the possible use of their data for research purposes.

For this study, 35 individuals were selected, including 20 females and 15 males in the age range 60-74 years, with different types of prosthetic oral rehabilitation and who met the following inclusion criteria: aged 60 years or over; dentures with adequate retention and stability, assessed by a dentist trained in rehabilitation and occlusion. Each prosthesis was evaluated for satisfaction, function, stability, quality and aesthetics, besides the vertical occlusion dimension. Exclusion criteria were: history of neurological, psychiatric and oncologic diseases in the head and neck; presence of dentofacial abnormalities or deformities; laryngeal surgery; alcoholism, smoking or medications that could cause xerostomia, such as antidepressants, antispasmodics, bronchodilators, anticholinergics, antihistamines and sedatives.

Procedures

Chewing evaluation

Chewing assessment was recorded on video and the following aspects were considered from the analysis of the footage:

- Masticatory type: from the visual counting of the number of chewing cycles (CC), according to the literature(17), being considered as bilateral alternate (CC occurred 50% of the time on each side of the oral cavity, or still 40% on one side and 60% on the other); simultaneous bilateral (CS occurred 95% of the time on both sides); unilateral preference (CC from 61% to 94% of one side); chronic unilateral (CC from 95% to 100% on the same side). Bilateral patterns (alternate and simultaneous), were considered as suitable, while the preferential and chronic unilateral patterns were defined as inadequate.
- Bolus formation capacity: patients were requested to keep their lips apart so as to allow the visualization of the formation of a homogeneous mass on the longitudinal groove of the tongue, for a classification according to the presence or absence of bolus formation(18).
- Bolus seizure: with the front teeth (normal pattern), with the lateral teeth, breaking the food with the hands or tearing the food using the teeth and hands (altered patterns)(18).

- Chewing time (represented by the length of grinding, spraying, organization and further propelling of the bolus by the tongue before being swallowed). The patients were instructed to perform the chewing of the food concomitantly with the timer shooting, which was stopped when viewed the movement of larynx elevation for swallowing, the results being accomplished in seconds[19].
- Other behaviors associated with chewing (altered head position, anterior escape of food and head movement): presence or absence was considered, according to the Orofacial Myofunctional Assessment Protocol with scores[20].

Oral DCC assessment

Oral diadochokinesia assessment was performed, by repeating the "pa", "ta" and "ka" syllables, of the tri-syllabic "pataka" sequence, uninterruptedly. The subjects were instructed to perform emissions as soon as possible, for the given time, each emission being recorded for eight seconds. For analysis purposes, the first two and the last two seconds were excluded, considering the number of emissions performed for four seconds, in the interval from the third to the sixth second. The analysis of monosyllabic emissions was performed by the Motor Speech Profile Advanced Program (MSP), Model 5141, Version: 2.5.2 (KayPentax®), and the sampling rate of 11025 Hz used in the capture adjustment[21,22]. Chart 1 shows the parameters analyzed for monosyllabic emissions.

The DDK of the "pataka" sequence was analyzed quantitatively by the Mult Speech Main Program Model 3700, Version: 2.5.2 (KayPentax®), using the sampling rate of 11025 Hz for the spectrographic analysis. The counting of the number of fricative sequences and tri-syllables per second was conducted by the evaluator, manually, with the support of the visual and auditory track, after demarcation of the time to be analyzed.

All recordings of speech and voice samples were recorded directly into a laptop, in an acoustically treated environment (soundproof booth). The participants remained seated, with an AKG C 444 PP microphone, positioned, laterally, at 5 cm from the labial commissure.

Statistical analysis

The Spearman correlation test was used for the correlation between the chewing type and DDK, the Pearson test used for the correlation between the time and DDK, adopting the values of p <0.05 as significant ones. In relation to other associate behaviors, seizing of food and formation of bolus, there was no indication of the application of statistical tests, aiming at correlating the DDK findings, given the heterogeneity of the data found.

RESULTS

The results of chewing assessment, as for the masticatory type, seizure of the bolus, bolus formation and other associated behaviors (food escape, altered position and head movement) are shown in Table 1.

As following values in seconds were achieved for the individuals studied, as for the chewing time: minimum = 16.03s; median = 32.12s; average = 34.29s; standard deviation = 14.06s and maximum = 77.2s.

Tables 2 and 3 show the number of emissions per second of syllables' "pa", "ta", "ka", "pataka", indicating the quantitative measures and qualitative values of DDK, related to time and masticatory type.

The statistical analysis showed a positive correlation between the chewing time and the parameters which indicate DDK

Chart 1. Parameters of oral diadochokinesis considered in the analysis of monosyllabic emissions

Parameters		Unit	Comments
avP	Average DDK Period	ms	Median time among the vocalizations
avR	Average DDK rate	s	Number of vocalizations per second, which is the speed DDK
sdP	Standard deviation of DDK period	ms	
cvP	Coefficient variation of DDK period	%	Measures the degree of rate variation in the period, indicating the ability to maintain a constant vocalization rate.
jitP	Perturbation of DDK period	%	Measures the degree of variation from cycle to cycle in the period, showing the skill to maintain a constant vocalization rate.
cvI	Coefficient variation of DDK peak intensity	%	Measures the intensity degree of variation in the peak of each vocalization, indicating the skill to maintain constant intensity of vocalizations

Note: DDK = Oral diadochokinesis; avP = Average DDK Period; sdP = Standard deviation of DDK period; avR = Average DDK rate; cvP = Coefficient variation of DDK period; jitP = Perturbation of DDK period; cvI = Coefficient variation of DDK peak intensity

Table 1. Characterization of behaviors associated with chewing

		Number of individuals	Percentage
Masticatory type	Bilateral alternated	22	62.86%
	Bilateral simultaneous	4	11.43%
	Unilateral preference	6	17.14%
	Chronic unilateral	3	8.57%
Other behaviors	Food escape	1	2.86%
	Altered posture	2	5.71%
	Head movements	6	17.14%
Seizure of food	Anterior teeth	30	85.71%
	Lateral teeth	0	0%
	Tearing food	3	8.57%
	Break food with the hand	2	5.71%
Bolus formation	Appropriate/present	25	71.42%
	Partial/present	8	22.85%
	Inappropriate/absent	2	5.71%

Table 2. Results of oral diadochokinesis considering the number of emissions per second of "pa", "ta", "ka", "pataka"

Parameters		"Pa"	"Ta"	"Ka"	"Pataka"
avP	Mean	186.44	180.36	196.71	
	SD	± 39.50	± 31.57	± 39.04	
sdP	Mean	13.11	10.34	13.65	
	SD	± 9.10	± 4.17	± 9.20	
avR	Mean	5.48	5.65	5.23	1.93
	SD	± 1.06	± 1.01	± 0.94	± 0.26
cvP	Mean	6.84	5.67	7.00	
	SD	± 4.03	± 1.70	± 4.70	
jitP	Mean	1.55	1.28	1.55	
	SD	± 0.94	± 0.57	± 0.77	
cvI	Mean	2.14	1.89	2.29	
	SD	± 1.00	± 0.78	± 1.10	

Note: SD = Standard deviation; DDK = Oral diadochokinesis; avP = Average DDK Period; sdP = Standard deviation of DDK period; avR = Average DDK rate; cvP = Coefficient variation of DDK period; jitP = Perturbation of DDK period; cvI = Coefficient variation of DDK peak intensity

instability: cvi (p=0.033) of the syllable "ta" and jit (p=0.049) of the syllable "ka". The oral DDK correlated with the chewing time in the healthy elderly, showing that the higher the instability in the repetition of the movements of the tip and dorsum of the tongue, during articulatory production, the greater the time required for food grinding.

DISCUSSION

Physiological changes associated with aging result in difficulties in performing the functions of the stomatognathic system[23], thus, the assessment of masticatory function and motor skill of the tongue may be an important marker to identify chewing changes. Thus, this study sought to relate the findings of oral diadochokinesia to the chewing function in healthy elderly, aiming at investigating the relationship between oral motor coordination and performance of the function, in order to clarify evaluation findings and assist in the treatment.

The predominant masticatory type in the elderly assessed in this study was the alternate bilateral or simultaneous one. The same result has been found in another study in which the authors verified that the simultaneous bilateral chewing pattern predominated in dentate institutionalized elderly, users of complete dentures[24], differing in this respect, from the present study which assessed elderly people with different types of prosthetic oral rehabilitation.

Although studies evaluating the normality of chewing time for healthy elderly were not found, the average chewing time observed in the present study was 34.29s. The value of the masticatory time of individuals using dentures is close to that found in a study with subjects with natural dentition[19].

Head movement was the most prevalent behavior associated with chewing, in the present study, followed by altered posture and food escape. Studies show reciprocity between the function of mastication and changes in the head and neck[25], due to neural connections between the cervical sensory-motor and trigeminal systems[26]. In another study, the authors state that the bulk of the bolus and harder texture correlate with a greater head extension and greater amplitudes of mandible and head movement, during mastication[27]. Studies also show that extension, flexion and tipping movements of the head during chewing are expected[17,28,29], reinforcing the existence of simultaneous and coordinated activity between the muscles of the neck and jaw[26], although it is not clear how the regions affect one another[26]. In another study, the results showed exaggerated participation of perioral muscles and vertical jaw movements as movements associated with chewing, in institutionalized elderly[24].

As a tool of the chewing process, as stated in the literature[30],

Table 3. Emission values per second of "pa", "ta", "ka", "pataka" related to the chewing time and type

Emissions			avR	avP	sdP	jitP	cvP	cvI
"Pa"	Time	R	0.06	-0.12	0.11	0.06	0.19	0.06
		p	0.731	0.476	0.528	0.745	0.283	0.748
	Type	R	-0.10	0.08	0.00	-0.01	-0.09	-0.03
		p	0.554	0.629	0.978	0.956	0.615	0.843
"Ta"'	Time	R	-0.15	0.06	0.25	0.26	0.18	0.36*
		p	0.375	0.742	0.152	0.131	0.309	0.033*
	Type	R	0.05	-0.06	0.05	0.10	0.06	0.09
		p	0.778	0.728	0.783	0.574	0.753	0.588
"Ka"	Time	R	-0.08	-0.05	0.26	0.33*	0.23	0.29
		p	0.628	0.768	0.135	0.049*	0.185	0.090
	Type	R	-0.17	0.16	-0.13	-0.11	-0.23	-0.11
		p	0.319	0.370	0.446	0.518	0.179	0.531
"Pataka"	Time	R	-0.09					
		p	0.608					
	Type	R	-0.22					
		p	0.209					

* Significant values ($p<0.05$) – Spearman correlation test (correlation between masticatory function and the DDK); Pearson test (correlation between chewing time and the DDK)

Note: DDK = Oral diadochokinesis; avP = Average DDK Period; sdP = Standard deviation of DDK period; avR = Average DDK rate; cvP = Coefficient variation of DDK period; jitP = Perturbation of DDK period; cvI = Coefficient variation of DDK peak intensity

the ability to control the bolus is usually affected according to the functioning of the muscles and properceptors in the oral cavity. However, in this study, the predominance of bolus formation, classified as appropriate, was observed, demonstrating that the aging process does not seem to affect this aspect.

With regard to DDK quantitative measures, it was observed, in the present study, that the variation was lower for syllable "ka'' and higher for syllable "ta'', in the avR parameter. However, the variation was reversed in the avP parameter, being higher for the 'ka' and lower for 'ta'. Regarding the qualitative values of DDK, the variation was lower for the syllable "ta" and higher for the syllable "ka", in the sdP, cvP and jitP parameters. The cvI parameter also showed lower variation for the syllable "ta" and higher for the syllable "ka''.

The oral diadochokinetic performance can be influenced by age, as pointed out by the literature[13], in which the authors observed that the elderly have the time associated with alternated movements of tongue and lips, during the tasks of syllables repetitions, and that this time period was significantly lower, as compared to that of non-elderly adults. It was observed, in the literature, that as the complexity of oral DDK emissions increased, the number of syllables per second was gradually reduced in the elderly, as compared to that of the young, as well as less effort to produce labial phonemes, increasing the difficulty, progressively, from the tip of the tongue to its posterior part, probably owing to the aging process of the muscle groups involved in these tasks[14].

In this study, the statistical analysis showed a positive average correlation between the chewing time and the parameters which indicate DDK instability: cvI (p=0.033) for syllable '' ta 'and jitP (p=0.049) for syllable' 'ka' '. Thus, the results showed that the greater the instability of the emission intensity in the repetition of tongue tip movements and instability of the emission duration in the repetition of tongue dorsum movements, during articulatory production, the greater the time required for food grinding. Such results demonstrate that the changes associated with aging can influence the oral motor control, which may cause the decrease in the speech velocity[15], besides reduction in the speed of mastication. One possible explanation for these findings may be related to the decrease of tongue pressure, owing to age[9], and to the influence of senility on tongue motor skill, compared to dentate adults and elderly and complete denture users[10].

As evidenced, few studies link oral diadochokinesia to chewing. Consequently, further studies are necessary to investigate this relationship, considering that the values of oral diadochokinesia assessment, when associated with chewing can help in the orofacial myofunctional diagnosis and subsequent treatment of masticatory dysfunction in the elderly, with respect to the motor skill of the tongue, during chewing.

CONCLUSION

Oral DDK correlated with the chewing time in healthy elderly, showing that, the greater the instability in the repetition of the movements of the tip and dorsum of the tongue, during articulatory production, the longer the time to prepare bolus for swallowing.

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