

## Artigos originais

# Amplitude and speed of masticatory movements in patients with Parkinson's disease

## *Amplitude e velocidade dos movimentos mastigatórios em pacientes com doença de Parkinson*

Lucas Carvalho Aragão Albuquerque<sup>(1)</sup>

Hilton Justino da Silva<sup>(1)</sup>

Leandro Araújo Pernambuco<sup>(1)</sup>

Sandro Junior Henrique de Lima<sup>(1)</sup>

Daniele Andrade da Cunha<sup>(1)</sup>

<sup>(1)</sup> Universidade Federal de Pernambuco / Centro de Ciências da Saúde / Programa de Pós-Graduação em Neuropsiquiatria e Ciências do Comportamento, Recife – PE – Brasil.

Conflict of interest: non-existent

### ABSTRACT

**Purpose:** to characterize the amplitude and speed of masticatory cycles evaluated by electrognathography in one group of elder individuals and to compare these data with those of two other groups of Parkinson's disease subjects.

**Methods:** 42 volunteers participants in this study were divided into three groups: A with 15 volunteers, average age of 62 years, 8 females, B with 14 volunteers characterized by a Parkinson's hypokinesia, average age of 58 years, of which 7 are female, and C with 13 volunteers characterized by a Parkinson's tremor, with average age of 64 years, being 4 female. It was used the ANOVA test for difference of means with post-hoc Dunnett's contrast or Student's t-test, all at 0.05 significance level.

**Results:** there were greater differences between the means of groups A and B in the total number of masticatory cycles ( $A = 23.13 \pm 1.41$  B =  $18.21 \pm 1.70$ ) [ $p = 0.034$ ] and in the maximum mouth opening amplitudes ( $A = 34.66 \pm 2.04$  B =  $26.72 \pm 2.49$ ) [ $p = 0.018$ ], lateralization to the right ( $A = 7.02 \pm 0.59$  B =  $5.80 \pm 0.97$ ) [ $p = 0.036$ ] and left ( $A = 6.44 \pm 0.64$  B =  $3.35 \pm 0.80$ ) [ $p = 0.039$ ].

**Conclusion:** the elderly group exceeded the means, in the mandibular movement during chewing, of the rigid group of parkinsonians. We may conclude that factors such as parkinsonian stiffness are likely to compromise the chewing of individuals with Parkinson's disease.

**Keywords:** Mastication; Range of Motion, Articular; Parkinson's Disease; Mandible

### RESUMO

**Objetivo:** caracterizar a amplitude e a velocidade dos ciclos mastigatórios avaliados por eletrognatografia em um grupo de indivíduos idosos e confrontar esses dados com outros dois grupos de sujeitos com doença de Parkinson (DP) diferenciados pela característica motora predominante.

**Métodos:** os 42 participantes foram divididos em três grupos: A com 15 voluntários e média de idade de 62 anos, sendo 8 do sexo feminino; B com 14 voluntários Parkinsonianos com rigidez predominante e média etária de 58 anos, dos quais 7 eram mulheres; e o grupo C com 13 voluntários, com DP e tremor predominante, com média de idade de 64 anos, sendo 4 mulheres. Empregou-se o teste ANOVA para diferença de médias, com contraste post-hoc de Dunnett ou teste t de Student, todos em nível de significância de 0,05.

**Resultados:** houve maiores diferenças entre as médias dos grupos A e B no número total de ciclos mastigatórios ( $A = 23,13 \pm 1,41$  B =  $18,21 \pm 1,70$ ) [ $p = 0,034$ ] e nas amplitudes máxima de abertura de boca ( $A = 34,66 \pm 2,04$  B =  $26,72 \pm 2,49$ ) [ $p = 0,018$ ], lateralização para direita ( $A = 7,02 \pm 0,59$  B =  $5,80 \pm 0,97$ ) [ $p = 0,036$ ] e para esquerda ( $A = 6,44 \pm 0,64$  B =  $3,35 \pm 0,80$ ) [ $p = 0,039$ ].

**Conclusão:** tendo o grupo de idosos superado as médias, na movimentação mandibular durante a mastigação, do grupo de parkinsonianos com rigidez significativamente. Podemos concluir que, é provável que fatores como a rigidez parkinsoniana possam comprometer a mastigação de indivíduos com a doença de Parkinson.

**Descritores:** Mastigação; Amplitude de Movimento Articular; Doença de Parkinson; Mandíbula

Received on: July 19, 2016  
Accepted on: November 24, 2016

#### Mailing address:

Lucas Carvalho Aragão Albuquerque  
Av. Conselheiro Aguiar – 3321 apto. 305  
Recife – PE – Brasil  
CEP: 51021-020  
E-mail: fono\_lucas@hotmail.com

## INTRODUCTION

James Parkinson, in 1817, first described the clinical syndrome that was later to bear his name. Previously referred to as “paralysis agitans”, in the 19th century, the scientists gave credit to Parkinson by referring to the disease as “Parkinson’s disease” or “male die Parkinson’s disease (PD)”. These scientists also recognized non-tremulous forms of PD and correctly pointed out that slowness of movement should be distinguished from weakness or “lessened muscular power”.

It was discovery in 1960 that dopamine concentrations were markedly decreased in the cortex of patients with PD, freeing the way for the first trials of levodopa in PD patients the following year. More recently, increased oxidative stress, genetic mutations, mitochondrial dysfunction, inflammation and other pathogenic mechanisms have been identified as major factors in the death of dopaminergic cells in the brains of patients with PD <sup>1,2</sup>.

Briefly, the dopaminergic system has to control and regulate the inhibition and excitation of cortical structures responsible for muscle movement. The death of the dopaminergic cells, leads consequently to the incoordination of muscle movement, characterized by tremor, bradykinesia, slowness of body movements <sup>3-7</sup>. These factors represent the impact on the biomechanics of chew muscles derived from damage to structures belonged or related to the dopaminergic system.

One way to analyze this biomechanics is the measurement of amplitude and velocity of jaw movements, predictive variables such as kinematic changes. In this context, electrognathography (EGN), a method that applies the technology of tracking movements using magnetoresistive sensors, can be excellent means to obtain these data <sup>4,8</sup>.

The analysis of masticatory movements and its relationship with mandibular biomechanics in patients with PD was poorly reported in the literature, showing that patients with PD may present limitations in mouth opening amplitude <sup>9-11</sup> and decrease in the speed of mandibular movement <sup>12-14</sup>.

The investigation of the mastication movements is justified by the importance of chewing and swallowing to the quality and maintenance of life of PD patients. Considering that about 80 % of PD patients suffer from dysphagia and broncoaspirations<sup>3</sup>, which can be directly related to masticatory disabilities<sup>5-7</sup>.

It is beyond the scope of this study to characterize the amplitude and speed of masticatory cycles on

PD patients evaluated by electrognathography and comparing these data with those of the other group without PD.

## METHODS

The study was approved by the Ethics Committee in Research of the Hospital de Clinicas da Universidade Federal de Pernambuco (HC-UFPE), receiving the record CAAE No.15352913.3.0000.5208. The Resolution 196/96 of the National Health Council and the Helsinki Declaration of 2008 were followed.

Cross-sectional, observational and exploratory, case series-type with groups comparison study, conducted between February and July 2014. It included PD patients at the Department of Neurology – (HC-UFPE) and volunteers recruited at the Center for Health Sciences - UFPE, Brazil.

The type of sample was defined by the characteristics of the group of non-PD subjects. For this reason, it was adopted for these participants, non-probabilistic samplings, by accessibility or convenience, which builds on the subject specificity, as well as admits that they can represent the universe, by being a descriptive and exploratory study <sup>8</sup>.

To determine the sample size of these comparison groups, identified as PD-Rigidity group (also called group B) and PD-Tremor group (also called group C), it was assumed that the ratio of 1.0:1.0, 0.05significance level and 80.0%of evidence power estimated at 14 individuals in group B and 13 in group C, adequate estimates in order that group C retained more similar characteristics to the universe of PD patients.

Exclusion criteria for group A were: presence of neurological, neuromuscular or neurodegenerative diseases and clinical diagnosis of acute symptoms of temporal-mandibular disorders at the time of testing. Those included in group A were healthy elderly individuals, of both sexes, matched by sex and age with groups B and C.

Groups B and C had as common inclusion criteria being individuals of both sexes, dentate, belonging to the Centre for Health Sciences, Federal University of Pernambuco, not submitted to surgery in the head and neck regions; no complaints of dysphagia, not subjected to any physical therapy and/or speech treatment and no difficulty in understanding simple orders.

42 individuals of both genders participated in the study with the following distribution: group A composed of 15 volunteers, average age equal to 62.07 years,

group B including 14 volunteers, average age 58,06 years; group C consisted of 13 patients, average age 64,86 years.

### Phases of data collection

After reading and signing the Term of Free and Informed Consent, volunteers were submitted to specific physical and anamnesis exams, to fit the groups into the inclusion and exclusion criteria.

For the electrognathographic examination, the volunteer was instructed to comfortably sit in a chair with the head erect and eyes directed forward.

The equipment used was the electrognathographer model JT-3D®, BioRESEARSHbrand. The program applied for reading the captured data was the BioPak System.

In the collection of electrognathography parameters, a small magnet was originally fixed to the labial surface of the lower incisors corresponding to the midline level; and the head support was symmetrically regulated.

To evaluate the masticatory cycle, a volunteer was asked to chew 15 g of bread, Made with the same quality and quality of ingredients, by the same baker, in the same bakery and at the same day and time, for 20 seconds. The jaw function and the consequent movement of the magnetic sensor were captured by the electrognathographer, transmitted and recorded on computer, enabling the visualization and analysis of all intra-border mandibular motion graphics.

All measurements were summarized as mean, mean standard error, confidence interval at a 95% level, median and interquartile range. In the comparison among groups A, B and C, it was used the ANOVA test for differences between means. In cases with no significant difference, it was used the Dunnett's post-hoc contrast to identify differences among groups, assuming group A as a parameter. In cases with no significance by ANOVA, the t-test was used for difference of means, also admitting the group A as a parameter. In all tests, it was assumed 0.05 significance

level for rejecting the null hypothesis of equality of means between groups.

## RESULTS

The number of masticatory cycles of PD-Tremor subjects was similar to the groups A, but differed from the PD-Rigidity patients, who had a lower number of chewing cycles than the other groups, this difference was statistically significant (Table 1).

Hence the tendency that is resulted from the major number of masticatory cycles as differentiation of the groups at the expense of major difference between group A and group B, which reached statistical significance. However, there was no difference between group C compared with groups A and B.

Regarding the speeds of masticatory cycles, there was no statistical difference among groups in the maximum speed of mandibular displacement in both the mouth opening and closing. However, Group B was different from group A and C by having a lower average speed of mandibular movement. But, this difference was not statistically significant.

As the average of the maximum opening, evaluated in the frontal plane, it was identified that there was significant difference between group A and B, apparently the difference does not exist between group A and C.

The average maximum latero-retrusion, measured in the horizontal plane, had distinct behavior according to laterality. When shifted to the right, the group A values were close to the measurements in groups B and C. However, in the shift to the left, it was discovered it had been significantly lower in group B compared to the other two groups. From the comparison between group A, taken as standard, and the two other groups, it was found that normal patients had average maximum latero-retrusion to the left significantly higher than the groups with PD (Table 1).

**Table 1.** Statistical parameters of the masticatory cycle

Variables of the masticatory cycle	Study groups			P <sup>†</sup> value
	ELDERS (GROUP A) (N= 15)	PD-RIGIDITY (GROUP B) (N=14)	PD-TREMOR (GROUP C) (N=13)	
<b>Total number of cycles</b>				0,091
Mean (mean standard error)	23,13 ± 1,41	18,21 ± 1,70	20,1 ± 1,64	
Range interval	30,0 - 10,0	33,0 - 11,0	29,0 - 10,0	
P † Value	1.000	<b>0,034</b>	0,179	
Median	24,00	16,50	20,0	
<b>Amplitude of right lateralization (mm)</b>				0,036
Mean (mean standard error)	7,02 ± 0,59	5,80 ± 0,97	9,18 ± 1,07	
Range interval	11,0 - 3,6	11,7 - 0,60	16,3 - 3,30	
P † Value	1.000	0,285	0,079	
Median	6,90	7,20	8,80	
<b>Amplitude of left lateralization (mm)</b>				0,018
Mean (mean standard error)	6,44 ± 0,64	3,35 ± 0,80	4,15 ± 0,93	
Range interval	11,7 - 2,90	10,20 - 0,50	10,50 - 0,40	
P † Value	1.000	<b>0,006</b>	<b>0,049</b>	
Median	6,10	2,05	3,20	
<b>Maximum opening in the frontal plane (mm)</b>				0,039
Mean (mean standard error)	34,66 ± 2,04	26,72 ± 2,49	32,36 ± 2,05	
Range interval	46,40 - 18,60	37,0 - 7,30	43,5 - 21,1	
P † Value	1.000	<b>0,018</b>	0,441	
Median	37,50	30,30	32,65	
<b>Maximum opening speed (mm/s)</b>				0,191
Mean (mean standard error)	224,2 ± 19,51	187 ± 20,83	238,3 ± 19,30	
Range interval	363,0 - 74,0	333,0 - 96,0	336,0 - 82,00	
P † Value	1.000	0,203	0,614	
Median	224,0	166,0	254	
<b>Maximum opening closing (mm/s)</b>				0,160
Mean (mean standard error)	232,6 ± 23,18	189,2 ± 19,24	245,6 ± 20,10	
Range interval	418,0 - 63,0	279,0 - 61,0	382,0 - 121,0	
P † Value	1.000	0,165	0,678	
Median	219,0	185,5	246,0	

Notes:‡= p value calculated by ANOVA test associated with post-hoc Dunnett

† = p value calculated by the t test for differences in means comparing with the PD group

## DISCUSSION

In recent years, several studies have been conducted on the possible relationships of PD and decreasing and slowing of chewing movements<sup>9-16</sup>, but the literature has not described precisely what these changes are and how they can modify the chewing in PD patients. This identified difficulty is related to a very complex issue and the multiplicity of factors that could be involved.

The electrognathographic characterization of amplitude and speed of masticatory cycles in PD patients, in turn, has demonstrated an even more

complex mandibular biomechanics, which seemed to derive from the in coordination muscle movements, and has been influenced by the main motor characteristic of the disease<sup>12,13</sup>.

Recent researches conducted to characterize the central cortex mechanism in the masticatory cycle, show the need for synergism between the cortical areas involvement of the masseter muscles, temporalis and medium pterygoid in the mandible elevation, and the action of supra- hyoid muscles, anterior belly of digastric, milo-hyoid, genio-hyoid, lateral pterygoid,

mimic muscles, tongue muscles and those infra- hyoid, as mandible depressors muscles<sup>13</sup>.

Additionally, through electromyographic studies there was also evidence of synergism between the extensor and flexor muscles of the head on the cervical spine and the activity of supra- and infra-hyoid muscles, contributing to the motion stability of the masticatory cycle<sup>15</sup>.

In this context, it is possible to assume that PD promotes a new dynamics of the masticatory cycle, which seemed to have been evidenced in this study. Even considering that, in PD subjects, the chewing area is one that suffers less impact on the life quality issue compared to the speech loss and whit dysphagia; the findings presented here are relevant in understanding this new kinematics<sup>12,13,15,16</sup>.

This new kinematic consisted in reducing the number of masticatory cycles, with frequency changes and jaw lateralization direction, which seemed to have been dictated mainly by the PD process, since the difference was observed when comparing the group of Elders subjects with the members of the PD group (groups B and C).

Compensatory and adaptive features of the stomatognathic system related to the DP differential in the revelation of such data<sup>17-19</sup> also seemed to explain the changes in speed expressed in the number of masticatory cycles per second (cycles/20s), whose qualitative value prevailed over the appearance by dopaminergic decreased action of PD<sup>19</sup>, since the statistical significance was detected in group B, due to the smaller number of cycles per second and greater variation of velocity regarding group A.

The strongest suggestive evidence that PD might have contributed to masticatory adaptations was present in the maximum speed of mandibular displacement generally in the opening and closing, since group B resembled group C and differed from group A in the general displacement. As the literature shows, PD subjects have a decrease in the movements' velocity of the body and in the jaw muscles. The PD-rigidity group, showed the major decrease in the velocity parameters than the PD-tremor group, this data was not found in the scientific literature yet<sup>9-14</sup>.

Variables such as maximal mouth opening in millimeters, the maximum lateralization in millimeters showed significant changes. Although this finding has corroborated the evidence of Troche (2008)<sup>3</sup> that the masticatory characteristic is the most affected in PD, it is plausible to assume that measurements of

border movements may reveal significant statistical characteristics.

Additionally, the PD-Rigidity patients show an average maximum mouth opening evaluated in the frontal plane and maximum left latero-retrusion to the left smaller than those in the groups of PD-tremor and elder patients, showed for the first time the temporary or permanent disorder of stomatognathic functions, consequent to PD and attributable to incoordination of the stomatognathic regions. These data corroborate with several studies showing that Parkinson's patients, in general, have a decrease in the amplitude of jaw movement, but do not specify whether these changes are related specifically to the lateralization or mouth opening<sup>9-14</sup>.

## CONCLUSION

In conclusion, in the analysis of the suggested variables, changes of the masticatory cycle assessed by electrognathography allowed to prove the existence of compensatory and adaptive, such as: deviations in the mandibular movement trajectory, decrease in amplitude, velocity and lateralization of the food during chewing, traits in PD patients, resulting from the joint action of the dopamine factor and possibly changes attributable to rigidity and the tremor.

## REFERENCES

1. Hornykiewicz O. Basic research on dopamine in Parkinson's disease and the discovery of the nigrostriatal dopamine pathway: the view of an eyewitness. *Neurodegener Dis.* 2008;5(3-4):114-7.
2. Leopold NA, Kagel MC. Prepharyngeal dysphagia in Parkinson's disease. *Dysphagia.* 1996;11(1):14-22.
3. Troche MS, Sapienza CM, Rosenbek JC. Effects of bolus consistency on timing and safety of swallow in patients with Parkinson's disease. *Dysphagia.* 2008;23(1):26-32.
4. Ali GN, Wallace KL, Schwartz R, De Carle DJ, Zagami AS, Cook IJ. Mechanisms of oral-pharyngeal dysphagia in patients with Parkinson's disease. *Gastroenterology.* 1996;110(2):383-92.
5. Nagaya M, Kachi T, Yamada T, Igata A. Videofluorographic study of swallowing in Parkinson's disease. *Dysphagia.* 1998;13(2):95-100.

6. Ertekin C, Tarlaci S, Ayodogdu I, Kiylioglu N, Yuceyar N, Turman AB et al. Electrophysiological evaluation of pharyngeal phase of swallowing patients in patients with Parkinson's disease. *Mov Disord.* 2002;17(5):942-9.
7. Sarr MM, Pinto S, Jankowski L, Teston B, Purson A, Ghio A et al. Contribution de la mesure de la pression intra-orale pour la compréhension des troubles de la coordination pneumophonique dans la dysarthrie parkinsonienne, *Rev Neurol (Paris).* 2009;165(12):1055-61.
8. Marotti J, Galhardo APM, Furuyama RJ, Pigozzo MN, Campos TN, Laganá DC. Amostragem em Pesquisa Clínica: tamanho da amostra. *Rev. Odontol Universidade São Paulo.* 2008;20(2):186-94.
9. Robertson LT, St George RJ, Carlson-Kuhta P, Hogarth P, Burchiel KJ, Horak FB. Site of Deep Brain Stimulation and Jaw Velocity in Parkinson's Disease. *J Neurosurg.* 2011;115(5):985-94.
10. Umemoto G, Tsuboi Y, Kitashima A, Furuya H, Kikuta T. Impaired food transportation in Parkinson's disease related to lingual bradykinesia. *Dysphagia.* 2011;26(3):250-5.
11. Bakke M, Larsen SL, Lautrup C, Karlsborg M. Orofacial function and oral health in patients with Parkinson's disease. *Eur J Oral Sci.* 2011;119(1):27-32.
12. Yunusova Y, Weismer G, Westbury JR, Lindstrom MJ. Articulatory Movements During Vowels in Speakers With Dysarthria. *J Speech Lang Hear Res.* 2008;51(3):596-611.
13. Robertson LT, Horak FB, Anderson VC, Burchiel KJ, Hammerstad JP. Assessments of axial motor control during deep brain stimulation in parkinsonian patients. *Neurosurgery.* 2001;48(3):544-51.
14. Heckmann SM, Heckmann JG, Weber HP. Clinical outcomes of three Parkinson's disease patients treated with mandibular implant overdentures. *Clin Oral Implants Res.* 2000;11(6):566-71.
15. Robertson LT, Hammerstad JP. Jaw movement dysfunction related to Parkinson's disease and partially modified by levodopa. *J NeurolNeurosurg Psychiatry.* 1996;60(1):41-50.
16. Karlsson S1, Persson M, Johnels B. Levodopa induced ON-OFF motor fluctuations in Parkinson's disease related to rhythmical masticatory jaw movements. *J NeurolNeurosurg Psychiatry.* 1992;55(4):304-7.
17. Maltête D, Jodoin N, Karachi C, Houeto JL, Navarro S, Cornu P. Subthalamic stimulation and neuronal activity in the substantia nigra in Parkinson's disease. *J Neurophysiol.* 2007;97(6):4017-22.
18. Ericksson PO, Häggman-Henrikson B, Nordh H, Zafar H. Co-Ordinated Mandibular and Head – Neck Movements During Rhythmic Jaw Activities in Man. *J. Dent. Res.* 2000;79(6):1378-84.
19. Bumann A, Lotzmann U. *Disfunção Temporomandibular: Diagnóstico Funcional e Princípios Terapêuticos.* Porto Alegre: Artmed; 2002.