NEWLY DEVELOPED PORTABLE DEVICE FOR MEASURING TONGUE PROTRUSION FORCE

1Renata Maria Moreira Moraes Furlan, 1Amanda Freitas Valentim, 1Tatiana Vargas de Castro Perilo, 2Andréa Rodrigues Motta, 3Nádia Leite Milagres, 3Márcio Falcão Santos Barroso, 3Cláudio Gomes da Costa, 1, 5Estevam Barbosa de Las Casas
1Universidade Federal de Minas Gerais/Graduate Program in Mechanical Engineering, Belo Horizonte, Brazil
2Universidade Federal de Minas Gerais /Department of Speech Language Pathology and Audiology, Belo Horizonte, Brazil
3Universidade Federal de São João Del-Rei/Department of Electric Engineering, São João Del-Rei, Brazil
4Fundação Centro Tecnológico de Minas Gerais (CETEC)/Department of Physical Tests, Belo Horizonte, Brazil
5Universidade Federal de Minas Gerais /Department of Structural Engineering, Belo Horizonte, Brazil
Corresponding author email: renatamfurlan@yahoo.com.br, web: www.dees.ufmg.br/biomec

SUMMARY
Tongue strength is usually evaluated by speech pathologists due to its importance on the oral functions. However, this assessment is carried out in a subjective way, which makes the follow-up harder to be done. To solve this problem, the Biomechanical Engineering Group from Universidade Federal de Minas Gerais, developed a portable device to measure tongue protrusion force. The device consists of a thermoplastic mouthguard and three parts made of epoxy: a base, which is the support for the sensor; a guide, that fixes the sensor; and an applicator comprised by a puck and a disk which is compressed by the tongue of the individual. A computer program, developed using Matlab, shows the force time history registered by the system. The purposes of this study are to compare measures of maximum and average tongue force obtained by the newly developed device, between male and female, and to relate those measures with comfort and reported difficulty of the task.

INTRODUCTION
Tongue strength evaluation is important due to its effect in the functions of mastication, swallowing, suction, breathing and speech articulation. However, this assessment is usually carried out in a subjective way, according to the experience of the professional, which makes the diagnosis and the follow up harder to be done.

A device to access accurately oral forces, besides helping in clinical practice, could lead to a tighter control in research results for the area. Researchers in different parts of the world have developed instruments to quantify tongue force, but many of them have disadvantages such as not being sensitive enough to small changes in force, difficulties in positioning reproducibility, large size that makes transportation harder, force direction different from clinical evaluation and other specific issues.

In an attempt to address these problems, the Biomechanical Engineering Group from Universidade Federal de Minas Gerais, in an interdisciplinary project, developed a portable device to measure tongue force. The purposes of this study are to compare measures of maximum and average tongue force obtained by the newly developed device, between male and female, and to relate those measures with comfort and reported difficulty of the task.

METHODS
The device for measuring tongue protrusion force (Fig. 1) consists of a thermoplastic mouthguard adaptable to the dental arches of each patient and three parts made of epoxy: a base, a guide and an applicator. The base part fitted in the inner center of the mouthguard is the support to a force sensor and has four holes for the attachment of the guide part, responsible to the fixation of the sensor in the base part. The guide part has a hole in its center, and the applicator moves through it. The applicator consists of a disk which is in contact with the tongue and a puck fitted in the disk. The subject has to push the disk with maximal effort. The force is transmitted to the puck that compresses the force sensor. The puck is smaller than the sensing area and does not touch any of the edges of the sensing area, to ensure that the entire load path remains within this area and to avoid that the edges support some of the load, leading to erroneous reading.

Figure 1: Device for measuring tongue protrusion force

The parts were projected so that the distance between the place for incisor teeth support for the mouthguard and the plate is approximately 2.0 cm. A study found that tongue exerts its highest protrusion force when this distance is
1.9±0.7 cm [1]. A Flexiforce A201 (Tekscan, Boston, MA) resistive force sensor was used, due to its compact dimension and thickness and high durability. The sensing range of the sensor, from 0 to 110 N, was chosen based on the values of normal and impaired patient’s tongue force reported in the bibliographic review [1,2].

A computer program was developed using Matlab software. The program registers the complete force time history since the beginning of the test and calculates average and peak forces. Sampling rate was 10 Hz.

A cross sectional study was conducted with the approval of Ethics Committee from the University (authorization 008/10). Tongue protrusion force was measured in 20 subjects (10 male and 10 female) aged between 20 and 33 years old. For each trial, the mouthguard was inserted and fitted in the mouth of the subject who had 15 seconds for accommodation. After this period, the subject was instructed to push the plate by protruding the tongue as hard as possible, then holding it for 10 seconds. This procedure was repeated three times, with one minute interval between trials.

Maximum and average forces were calculated for each subject in each trial performed. Average force was defined as the average of the signal for 10 seconds of sustained contraction. Maximum force refers to the peak force in the considered time interval.

After that, each subject answered a questionnaire about comfort and difficulty of the evaluation.

RESULTS AND DISCUSSION
Table 1 shows average and maximum forces in Newton, for male and female. It was observed that men have statistically significant greater maximum and average force than women. This fact agrees with some authors [2,3] but does not agree with others that did not find difference in force between sexes [4].

Some participants reported feeling tired during (n=5), after (n=3), or during and after (n=2) the trials. Fig. 2 shows maximum forces on trials 1, 2 and 3 by subjects that related or not feeling tired during of after the evaluation. Participants that did not feel tired presented results that improved with the trials (p=0.006), maybe due to the learning effect [5]. The ones that felt tired showed no statistic significant differences between trials, presumably because the learning effect was combined with muscle fatigue.

As for the difficulties on the test, 16 participants said they had more facility in one of the trials (7 on trial 1, 4 on trial 2 and 5 on trial 3). However, there was no difference in values of maximum force comparing the easier trial with the other ones.

CONCLUSIONS
Men have significant greater average and maximum force than women. Subjects that felt tired had smaller values on the last trial and higher on the first one. There was no correlation between easier trial and higher maximum force values.

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REFERENCES

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F= female; M= male; SD= standard deviation; ‘= t-Test for independent samples; *= p<0.05