An index for the evaluation of 3D masticatory cycles variability

Matteo Zago, Claudia L.P. Ferreira, Francesca M.E. Rusconi, Claudia M. De Felicio, Chiarella Sforza

***Abstract*— A comprehensive index for the analysis of the inter- and intra-subject variability of the 3D masticatory cycles trajectories was introduced and assessed in a healthy group and in patients with temporomandibular disorders.**

I. Introduction

Evaluating the chewing process allows for diagnosing dysfunctions of the stomatognathic system, especially in cases of temporomandibular disorders (TMD). Some authors investigated within-subject variability in masticatory cycle (MC) 3D kinematics [1]. However, a unique variability index involving the whole set of parameters of the MC is still not available. The aim of this study is to introduce the Masticatory Stability Index (MSI) and to test it on two groups of healthy participants (HP) and TMD patients.

II. Methods

A. Participants and procedures

48 subjects were divided into two matched groups (HP and TMD: 10 men, 14 women; age 21 y (SD, 4)). TMD inclusion criteria: to have a short lasting TMD (<6 months) with mild-moderate signs and symptoms severity; to have not sought care to TMD. The MCs were recorded during 30 s-unilateral chewing of a sugarless gum (1.5 g), using an optoelectronic motion capture system (BTS, Italy). Mandibular motion was tracked with passive extraoral markers; intraoral anatomical calibration allowed to reconstruct the 3D trajectory of the intra-incisal landmark in the head local coordinate system [2].

B. Data reduction

The developed algorithm selected MCs starting from centric occlusion, longer than 300 ms and higher than 3 mm. Matlab software was designed to compute: (i-iii) duration, velocity, length of the MC; (iv) subtended area; (v) shape of the trajectory, i.e. the ratio between 1^{st} and the 2^{nd} eigenvalues of the [$2\times n$ samples] matrix describing the MC on the frontal plane; (vi) eigenvector slope (inclination) with the vertical axis; (vii-ix) RoM along the spatial directions. The 20 most representative MCs were retained [1]. Then, a procedure to quantify the fluctuation magnitude of chewing parameters was adopted [3]. The correlation coefficients c_n between the first Principal Component of the dataset (PC1) and variables p_n were calculated. The raw index was:

$$MSI_{raw,i}=\ln(\|s_i - s_{HP}\|) \quad (1)$$

where s_i is the sum of the $p_n \cdot c_n$ products for a subject i, and s_{HP} is the mean of the s_i in the HP. After computing the number of SD separating the i-th subject from the raw score of the HP ($zMSI_{raw,i}$) the final index is obtained:

$$MSI_i = 100 - 10 \cdot zMSI_{raw,i.} \quad (2)$$

The mean score (SD) of the HP is 100 (10). Each 10-points difference corresponds to a separation of one SD from the HP variability score. Based on clinical assessment, we considered preferred chewing side (PS) and non-preferred chewing side (NPS); 2-way ANOVA (factors: group, side) was used to test differences in MSI (α: 5%).

III. Results

The MSI showed greater variability for TMD on both sides: PS, 98.7 (8.13), NPS, 95.5 (6.25), $p<0.05$, 2-way ANOVA, group factor.

IV. Discussion and conclusion

Intra-subject repeatability offers a great potential for understanding the neuromuscular control of chewing, and the pathophysiology of certain diseases [1].

Chewing is normally variable, but an increased variability in jaw movements in the absence of pain may reflect a persistent decrease in the excitability of the face motor cortex [4]. The current findings of lower repeatability of MC in TMD patients are consistent with previous reports of major irregularities and variability of masticatory function [2]. Alterations in the somatosensory input to the motor system because of the discomfort on joints (pain and noise) and muscles, together with possible biomechanical impairments, may be present. These preliminary results encourage validating the index on a larger sample.

References

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M. Zago is with Università degli Studi di Milano, dpt. of Biomedical Sciences for Health, Milano, 20133, Italy (corresponding author, phone: 0039 02 503 15357; fax: 0039 02 503 15387; e-mail: matteo.zago@unimi.it).

C.L.P. Ferreira, F.M.E. Rusconi, C. Sforza are with Università degli Studi di Milano, dpt. of Biomedical Sciences for Health (e-mail: claudialpferrerira@gmail.com, francesca.rusconi7@gmail.com, chiarella.sforza@unimi.it).

C.M. De Felicio is with School of Medicine, Ribeirão Preto - Craniofacial Research Support Centre, University of São Paulo, Brazil (e-mail: cfelicio@fmrp.usp.br).