

# **STIFFNESS OF THE HUMAN LIPS IN PARKINSON'S DISEASE**

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Perioral stiffness was sampled from normal adults and individuals with Parkinson's disease. A digitally-controlled linear servo motor produced a lateral tangential stretch of the oral angle during a rest condition. Quadratic modeling indicated significantly greater perioral stiffness functions in PD (re: Normal) that were dependent on medication level.

Biomechanics are central to the study of speech motor control. Muller et al. (1985) provided some of the first observations on perioral tissue biomechanics in adult subjects, including span-tension and force-velocity relations. In disordered neuromotor control systems, long-term changes in the biomechanics of articulatory systems has been implicated in various forms of kinematic dysfunction, in hypokinetic dysarthria and other motor speech disorders. Hunker et al. (1982) quantified muscle rigidity in the labial muscles of parkinsonian and normal subjects by applying midline compression forces to the lip vermilion and observed the resultant displacements to estimate labial stiffness coefficients. Subsequently, labial speech movements were sampled from these same subjects to evaluate hypokinesia on lip kinematics. Labial rigidity was positively correlated with decrements in the range of lip movement. Electromyographic recordings from orbicularis oris and mentalis muscles indicated a causal relationship between rigidity and hypokinesia. Therefore, the application of biomechanics to the clinical study of speech/vocal tract movements has potential value in furthering our knowledge on the effects of neuromotor disease on fine motor control. The objective of the current report is to detail a new computerized application for high-speed sampling and measurement of perioral stiffness using a specially designed servo-controlled linear motor. It is likely that passive and active components of span-tension functions for the oral angle will provide clinicians with a new non-invasive predictive tool for assessing residual motor function in relation to perioral kinematics during nonspeech and speech motor activities in a variety of neurological populations.

### **Subjects and Test Methods**

Thus far, 10 healthy adults served as the control group, and their data were pooled for comparison. Our ongoing experimentation is concentrated on a group of 20 Parkinson's patients studied at the University of Kansas Movement Disorders Clinic in the Department of Neurology. Each subject completed a written informed consent in compliance with the University of Kansas Human Subjects Internal Review Board. Subjects were seated in a dental examination chair with the head positioned comfortably against padded occipital cups. Subjects were instructed to look straight ahead and relax the facial muscles. One adult male (age 61 yrs.; 10 mos.) diagnosed with Parkinson's disease five years ago is highlighted in the current summary.

A custom designed linear servo motor, capable of 50 mm of translation and sampling 10 Newtons of force, was positioned to impose sequential ramp-step displacements at the right oral angle under position feedback. A stator hook referenced to the housing of the linear motor was

positioned at the contralateral oral angle. The data acquisition microprocessor was programmed to generate an automated sequence of 8-step displacements at the oral angle. Each step was 3 millimeters and was sustained for 3 seconds before the 16-bit digital-to-analog converter produced the next step. The transition time between steps was 100 ms to reduce the possibility of evoking a stretch reflex. A single data block consisting of 8 imposed tangential displacements was completed in 27 seconds. Five data blocks were recorded for each subject. Those in the experimental group underwent protocol with two conditions, first with no medications (OFF) then again thirty minutes after consuming their prescribed anti-Parkinson's medication (ON). Motor input, load cell, and LVDT (displacement) signals were digitized at 100 samples/sec at 16-bits of vertical resolution. A software analysis program written in MATLAB v6.2 reduced the force and displacement signals to a series of passive stiffness coefficients plotted as a function of oral angle displacement and fit using nonlinear regression techniques.

### Results

Control group: Quantitative measures of stiffness sampled at the oral angle were completed in approximately 3 minutes for each subject within the control group, including data acquisition and digital signal processing. For all healthy subjects tested thus far, a quadratic equation provided a statistically significant fit to the experimental data [ $F(2, 347) = 184.14, p < 0.0001$ ]. The regression equation is  $\text{Stiffness (N/mm)} = 0.0593752 - 0.0026314 \text{ Interangle Span} + 0.0002303 \text{ Interangle Span}^2$ .

For the sample Parkinson patient in the medication OFF condition, the stiffness function was significantly elevated above the control function contributing to the clinical perception of muscle rigidity. A quadratic equation provided a statistically significant fit to the experimental data [ $F(2,32) = 53.69, p < 0.0001$ ]. The regression equation is  $\text{Stiffness (N/mm)} = 0.118658 - 0.0088469 \text{ Interangle Span} + 0.0008236 \text{ Interangle Span}^2$ . The PD patient was then given his anti-Parkinson medications, and after 30 minutes the stiffness test was repeated. In the medication ON condition, the stiffness function was significantly related to interangle span but was consistent with the stiffness coefficients exhibited in neurological normal subjects. A quadratic equation provided a statistically significant fit [ $F(2, 32) = 207.19, p < 0.0001$ ]. The regression equation is  $\text{Stiffness (N/mm)} = 0.0337784 - 0.0017594 \text{ Interangle Span} + 0.0003643 \text{ Interangle Span}^2$ .

These preliminary data illustrate the sensitivity of tissue biomechanics to reflect the underlying neuromotor state in Parkinson's disease. The quantitative correlate of muscle

rigidity, namely stiffness, can be rapidly and accurately sampled using this new computerized technology in cooperative subjects. Biomechanical measurements should be possible and clinically useful when applied to other forms of progressive neuromotor disease (i.e., multiple sclerosis, ALS) and acquired insults to the nervous system (stroke, traumatic brain injury) in determining the effects of medication and neurosurgical therapies (deep brain stimulation, fetal grafts, ablation). Given the inverse relation between increases in muscle rigidity (stiffness) and speech kinematics, it becomes increasingly important to understand the mechanisms of neuromotor disturbances that affect speech and voice production.

### **Literature Cited**

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