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### A Myometric Evaluation of Certain Aspects of the Perioral Musculature in Individuals with Demonstrable Adverse Swallowing Patterns

John Milford Anholm

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LOMA LINDA UNIVERSITY  
School of Graduate Studies

A MYOMETRIC EVALUATION OF CERTAIN ASPECTS OF THE  
PERIORAL MUSCULATURE IN INDIVIDUALS WITH  
DEMONSTRABLE ADVERSE SWALLOWING PATTERNS

by

John Milford Anholm

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A Thesis in Partial Fulfillment  
of the Requirements for the Degree

Master of Science in the Field of Orthodontics

June 1962

60371

I certify that I have read this thesis and that in my opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Science.

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## CHAPTER I

### INTRODUCTION

Object of the Investigation. Tooth position is governed in part by the orofacial muscular complex. This concept has been advocated historically by Angle (1900), Rogers (1918, 1936), Brodie (1950) and many others. Definitive work has been reported recently using varied approaches and different technics which would tend to confirm the above hypothesis.

It can be postulated, therefore, that a change in muscle function will result in a concomitant change in tooth position. Changes in function have been described by measuring changes in magnitude of force, duration, direction, frequency and/or sequence. It is the purpose of this study to determine the magnitude of force, and its duration, exerted by the perioral musculature during several defined acts in normal subjects, and to compare these measurements with those obtained from a comparable group exhibiting a well-defined malocclusion with clinically demonstrable adverse lip functions.

Definition of Terms. For the purpose of this discussion the following definitions will apply:

1. Adverse swallowing, adverse pattern of swallowing, or adverse swallowing behavior may be defined as the act or pattern employed in swallowing which, if persisted in, will lead to conditions that are detrimental to the occlusion. This has been variously described in the literature as perverted swallowing (Straub 1951), visceral swallow (Gwynne-Evans 1954), tooth apart swallow (Beresford 1956), infantile



swallowing pattern (Moyers 1958), seventh nerve swallowing (Moyers 1958), tongue thrusting (Jann 1960, Andrews 1960), reverse swallowing (Keisel 1961, Straub 1960), abnormal swallowing (Drewer and Vijoen 1961).

2. The environmental musculature of the teeth is the orofacial musculature including the lingual musculature.

3. Myometric pertains to the measurement or assessment of the pressures or forces resulting from muscular contraction.

4. Psi is the abbreviation for pounds per square inch.

5. Psi/sec is the abbreviation for pounds per square inch per second.

## CHAPTER II

### REVIEW OF THE LITERATURE

Current orthodontic literature is becoming increasingly occupied with the oral facial musculature and its effect upon the denture and its supporting base. Historically, Angle (1900) was among the first to recognize the importance of this musculature on positioning of the teeth. Rogers (1918), with his classical presentation of the problem, kept the thought alive, and introduced the idea that tooth position could be altered by a rigorous training program of the environmental musculature. This is popularly known as "Rogers' Myofunctional Therapy." This work, while widely read, found little acceptance clinically.

Post-war orthodontics, with its research emphasis, explored a number of aspects of the oral facial complex and provided an increased fund of knowledge as to the physiology and anatomy of these structures. Notable in this area is the work of Thompson (1949), Brodie (1950), Tully (1958), DiSalvo (1961), Wildman (1961) and others.

The act of swallowing, and especially the associated movements and the position of the tongue, has been studied and reported in some detail by many investigators. Of particular note is the work of Straub (1951, 1960), Gwynne-Evans (1952, 1958), Syrop (1953), Ardron and Kemp (1955), and Tully (1956, 1958, 1959, 1960). Jann (1960) reported on the distortion of speech sounds associated with adverse swallowing patterns.

In addition to this physiological approach, a study of the morphological factors involved has been made. Margolis (1947), Bowker (1959), Burstone (1959), Subtelny (1959), Bloom (1961) and others have

worked out ways to quantitatively assess the relationship of the facial profile to the dental structures.

Prominent among the methods used for quantitative assessment of the physiology of these structures are various modifications of the electronic strain gauge. A technic using a strain gauge and a Brush direct inking oscillograph to produce a graphic record is described by Winders (1955). From the data reported it is concluded that there is an apparent imbalance of the muscular forces acting on the dentition between the lingual and the buccal sides, with the greater force being exerted by the tongue.

Winders again in 1958, 1959, reported on the forces exerted on the dentition by the perioral and lingual musculature during swallowing. After comparing the findings in those with normal and abnormal occlusion, he concluded that: (1) there is no statistically significant difference between the pressures incurred during swallowing in the normal group as opposed to the Class II, Division I malocclusion group; (2) there is no statistically significant correlation between the swallowing pressures and the anterior-posterior position of the teeth; (3) in function, as he had previously observed, the tongue exerts a much greater force on the dentition than does the perioral musculature.

Winders (1962) uses a graph to show the pressures he obtained for resting pressures, swallowing pressures, and maximum effort pressures. He states that these "pressures range from 0-2,000 g/cm.<sup>2</sup>" (0-28.4 psi). Resting pressures shown by Winders are small in magnitude, ranging from 0-15 g/cm.<sup>2</sup> (0-.2 psi). Swallowing pressures reported for the perioral musculature remain the same as resting pressures for a normal swallow. His report did not include results for adverse swallowing.

Moyers (1958) also refers to the changes in lip and tongue pressures during adverse swallowing, and discusses a theory of its etiology in his Handbook of Orthodontics.

Kydd (1956) reported on methods of measurement of the pressures exerted by the tongue on the dentition. Kaires (1957) corroborated these findings in similar studies utilizing a denture prosthesis, showing that his method was practical. Kydd (1957) reported the maximum effort pressures that the perioral musculature exert against the labial surface of the anterior teeth and adjacent gum area was: median of 4.4 psi for the maxillary tooth area (range 1.9 - 6.3 psi) and 4.1 psi median for mandibular tooth area (range 1.3 - 6.3 psi).

Kydd made the following observations: (1) The force of both the lip and the tongue, if unopposed by each other, appears to be great enough to move teeth. (2) The pressures exerted by the tongue are normally greater than the pressures exerted by the lips. This is in disagreement with the hypothesis of Rogers, Brodie and Breitner, which states that the force of the tongue from within the dental arches is normally compensated for by the action of the musculature of the lips and cheeks.

To explain this apparent imbalance, Kydd (1957) makes the following statement:

Again, other forces which tend to equalize this apparent imbalance of musculature may be brought into play. These forces may include the inclination of the teeth, the density and thickness of alveolar bone, the length of the tooth roots, the length of the clinically apparent crowns, and the forces of occlusion. The lips may exert a lower pressure for a longer duration than the tongue. These speculations provide worthy material for subsequent investigations.

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It is within this frame of reference that the present study is undertaken, i.e., to measure the forces of the perioral musculature and to relate these forces to a time base.

## CHAPTER III.

### TEST MATERIALS AND METHODS USED

The equipment used in this study for measuring the forces exerted by the lips against the maxillary central incisor area and the mandibular incisor area consisted of a cast rubber pressure sensing device 1 cm. square, coupled at one corner to a Statham model p-23 AC pressure sensitive transducer by small, relatively inelastic polyethylene tubing. The tubing used was Intramedic type PE 100 with an inside diameter of .034 inches and an outside diameter of .060 inches.

The signals from the transducer were recorded by a Sanborn Model 60-1300 Twin-viso, two-channel, hot-stylus recorder equipped with two model 64-500A strain gauge amplifiers. (Illustration 1)

The rubber intraoral recording cushion was made of self-curing liquid latex rubber of very thin walls, insuring maximum sensitivity. The entire pressure sensing system was filled with distilled water, care being taken to remove all air. In this way pressures were transmitted from the sensing cushions to the transducers via a relatively non-compressible medium.

The pressure sensing cushions as constructed were 1 cm. square, and were approximately 2.5 to 3 mm. thick when filled with water as used for testing. The cushions were prepared by casting the latex around a wire frame, which was outside the 1 sq. cm. area used for testing. From this frame arms extended bilaterally. The sensing cushions were stabilized in the mouth by ligating the lateral arms to the teeth with dental floss. The pressures exerted in the area to be

surveyed could be consistently recorded during speaking, swallowing, drinking, or other maneuvers desired of the lips without displacement of the cushion. (Illustrations 2 and 3) This method gave very consistent results, and is supported by the work of Feldstein (1950), Margolis and Prakash (1953), Kydd (1956, 1957), Sims (1958), and Winders (1959, 1962).

The subjects selected for this research consisted of two groups: a study group and a control group. The study group was selected from individuals desiring orthodontic treatment at the Loma Linda University School of Dentistry. These subjects, who exhibited adverse swallowing patterns, were divided into two groups: those who demonstrated evidence of a mentalis habit and those who did not. Only those who had an adverse swallowing pattern accompanied by a mentalis habit were used in this study. The group consisted of seven girls and four boys. The mean age of these subjects was nine years five months, with a range from seven years two months to thirteen years ten months.

The control group was selected from the fifth grade classrooms of Loma Linda Elementary School, and were selected on the basis of having acceptable occlusion with no demonstrable evidence of abnormal tongue habits. Acceptable occlusion, in this investigation, was characterized by: Class I (Angle) molar relationship, good symmetry in both arches, evidence of a normal eruption sequence and pattern, no excessive overjet and overbite, and freedom from crowding. Six subjects were selected for the control group. Their mean age was eleven years seven months, with a range from ten years nine months to twelve years one month.

Stone casts of both arches were prepared from alginate impressions. Pressure recordings of the lips, using the instrument previously described, were also taken.

The 1 cm. square intraoral recording cushions were centered on the gingival crest of the maxillary and mandibular central incisors, thus extending 1/2 cm. on the tooth and 1/2 cm. on the gingival area.

During the recording session the patient was seated in a comfortable chair and was told that he had been chosen to help in a scientific study on the functions of the lip. He was then shown the pressure recording cushions and told that these would be placed in his mouth, and that they would be held in place comfortably for the next few minutes.

The recording cushions were calibrated prior to each recording as follows: A pressure equivalent of 1 psi was introduced into the system by means of a sphygmomanometer bulb and gauge, and while under pressure of 1 psi, the recording instrument was calibrated so as to give a deflection of the recording stylus of 25 mm. This was found to be a reliable means of calibration. At the conclusion of each recording session a check was run to see if there had been any drift or change in the calibration during the recording period. This was usually found to be negligible and of no practical consequence. The speed of the paper under the writing stylus was set so all recordings were made with the speed of 1 cm. per second.

The test situation consisted of the following procedures:

- a. The patient was requested to drink some water from a paper cup.
- b. The recording instrument, which had been allowed to run prior to the giving of the instructions to the patient, was left on until a spontaneous swallow had been recorded.
- c. The patient was then asked to swallow at two different times, no water being provided.



d. The patient was asked to say the word "puppy" once, and was then asked to repeat the word five times at the normal speed of talking.

e. The word "firefly" was then recorded in a similar fashion.

f. The words "thick toothbrush" were recorded as above.

g. The patient was asked to press his lips very tightly against his teeth.

h. The operator held the lips away from the cushions for a few seconds so that no lip pressures could be exerted against the cushions. The lips were then released.

i. The cushions were removed from the teeth and placed between the lips so that the interlip pressure could be recorded. The maximum interlip pressure the patient could exert was recorded at the center of the mouth and at the corner of the mouth.

j. The interlip pressure at the center of the mouth and at the corner of the mouth was recorded when the patient swallowed on command.

The sensitivity of the recording instrument is demonstrated in a recording analysis of the word "puppy." (Illustrations 6 and 7) It will be noted that the two syllables of the word "puppy" are distinct, with the pressure between the syllables returning to near its resting level.

The words or phrases used in the recording of lip pressures during speech sounds were selected on the basis of the specific presence or absence of lip function required in their production. They had been recommended by the University Speech Pathologist, Lutz (1961). The word "puppy" was chosen because it is a bilabial sound and requires the approximation of the lips in producing it. The production of the word "firefly" requires a high degree of function of the lower lip, while

the upper lip function is negligible. The phrase "thick toothbrush" does not place primary emphasis on lip function, even though the bilabial sound [b] is included toward the end of the phrase. It was felt that these words gave ample opportunity to explore lip functions in conjunction with speech sounds.

The reason for asking the patient to repeat the word or phrase several times is that a word spoken upon request is produced by conscious effort, but when that word is repeated several times in succession, conscious effort is greatly reduced and a more spontaneous pattern is reflected.

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## CHAPTER IV

### RESULTS AND OBSERVATIONS

All subjects in the study group exhibited Angle Class II, Division I malocclusion. Illustration 5 is a representative study cast for this group. Excessive overjet (horizontal overlap) of the maxillary anterior teeth was observed in all subjects. Five of the subjects exhibited an open bite in the anterior region, and six exhibited a closed bite with the lower anterior teeth occluding into or near the palatal tissues. Eight of the eleven subjects exhibited a collapse of the lower arch with crowding. These also routinely exhibited asymmetry in the anterior regions. One of the three who did not show this crowding exhibited excessive spacing of the lower anterior region, with a flaring of the lower anterior teeth.

A majority of the study group exhibited early signs of periodontal involvement in the region of the lower incisor teeth. This ranged from mild hypertrophy of the gingivae to stripping of the gums from the necks of the incisor teeth.

Two of the study group had previous traumatic accidents involving their maxillary teeth: one exhibiting minor chipping of the mesioincisal angles; the other having two maxillary central incisors capped with plastic jacket crowns. One subject displayed an excessively high and narrow palatal vault. It was noted, however, that no one in this group had a low flat vault. Nine of the group were in the late mixed dentition. All others were in the permanent dentition.

Six subjects were selected for the control group. Two were in the late mixed dentition; all others were in the permanent dentition.

All the control group revealed symmetry of arch form in both the maxillary and mandibular arches, with no severe rotations in teeth present. The palatal vaults of these were of normal height and width. No periodontal involvement nor evidence of trauma to the maxillary anterior teeth was noted in this group. Illustration 4 is representative of the study casts of one of the control group.

The mean pressures measured for the study and control group under each of the experimental conditions and standard deviations for each group are shown in Tables 1-4. It was noticed that means of measurements of pressures obtained from subjects comprising the control group were greater than those obtained from subjects of the study group in nineteen of the twenty-eight situations studied. The means of pressures obtained from the study group were greater than those obtained from subjects of the control group in the following areas: drinking, upper lip; volitional swallow, lower lip; word #3, "thick toothbrush"; upper lip in forces exerted; maximum effort pressures, lower lip; between lips, maximum pressures at center and at corner of mouth; between lips, volitional swallow at center and at corner of mouth.

It is not proposed to do a definitive statistical study with a sample of this size and range. However, statistical analyses can be of value in pointing out the test situation in which possible differences can occur, the direction measurements tend to differ, and possible relationships of these differences among several tasks.

The significance of the difference between the means of the measures for the control group and study group were determined by t tests. These are shown in Tables 5-8. An asterisk is placed after

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each t value which is significant at the 5 per cent probability level. Two asterisks are placed where the t value is significant at the 1 per cent probability level.

It will be seen that most of the t values given are of no significance at the 5 per cent level, which is quite understandable. By chance alone one would expect one or two of the twenty-eight measurements of pressures analyzed to show t values at the 5 per cent level of significance, but ten of the twenty-eight t values are of significance at the 5 per cent level, and of these, three are significant at the 1 per cent level of probability. This is sufficiently frequent so that it is not likely that these figures happened by chance alone, even in a small sample. Significant t values were distributed among the different measurements of pressures as follows:

Two were significant for maximum pressures recorded.

Two were significant for maximum pressures during speech sounds.

Four were significant for forces exerted.

Two were significant for between-lip pressure recordings.

During the act of talking, as sampled by the words used in this investigation, the maximum pressures exerted by the lips against the teeth were greater in the control group for all words. The pressures were also greater in the control group when figured in terms of psi/sec with but one exception--the upper lip during the word "thick toothbrush"--where the mentalis group showed a slightly greater pressure, but not of sufficient magnitude to show a t value of significance.

The maximum pressures exerted by the upper lip of the control group during the recording of the words "puppy" and "firefly" show a t value of significance at the 5 per cent level when compared with the

study group. When measured in psi/sec, the mean for the upper lip of the control group was significantly greater than that of the study group at the 5 per cent level for the word "puppy," and at the 1 per cent level for the word "firefly." See Illustrations 6 to 11 for records obtained of speech sounds from control and study groups.

The greater pressures of the lips of the control group during speaking would seem to indicate that the lips of a person with "normal" occlusion and "normal" swallowing patterns exert greater pressure against the teeth than the lips of a person with adverse swallowing patterns exhibiting mentalis habit. Further studies are necessary to test this hypothesis.

Maximum effort pressures exerted against the maxillary anterior teeth of the control subjects were significantly greater than those of the study subjects at the 5 per cent level, whereas the maximum effort pressures exerted against the mandibular anterior teeth of the study subjects were slightly greater than those of the control subjects, but this is not statistically significant. The control group demonstrated significantly greater pressures than the study group in all areas of measurement with the exception of the inter-lip pressures. (See Tables 5 to 8) The t values for the greater inter-lip pressure exerted by the study group are significant as follows:

At the 5 per cent level at the corners of the mouth during maximum pressure exerted.

At the 1 per cent level at the corners of the mouth during volitional swallow.

Pressures at the center of the lips are of no significance by the t test.

## CHAPTER V

### DISCUSSION AND CONCLUSIONS

The muscles of the mouth can be divided into two groups. One group closes the lips, and consists of various parts of the orbicularis oris muscle, and the mentalis muscle. The second group opens the lips, and consists of radially arranged muscles.

Descriptions of the orbicularis oris and mentalis muscles are included by way of review, as the contraction of these muscles is primarily responsible for the pressures recorded in this study. The orbicularis oris--the complex muscle surrounding the mouth--is not just a simple sphincter muscle. It has no direct attachment to the skeleton. Occupying the entire width of the lip, it consists of numerous strata of muscular fibers surrounding the orifice of the mouth but having different directions. Its fibers can be classed as an upper and a lower group which cross each other at acute angles at the corner of the mouth. From each of the retractor muscles of the lips fiber-bundles are continued into the more peripheral and superficial portions of the orbicularis oris, thus forming an interlacing network of muscle fibers.

The mentalis muscle is a short, thick, conical muscle that arises from the incisive fossa of the mandible, and descends to insert into the skin of the chin. Its action is to draw up the skin of the chin and thus assist in protrusion or eversion of the lower lip.

The maximum effort pressures that the perioral musculature exert against the labial surface of the anterior teeth and adjacent gum areas, as reported by Kydd (1957) and Winders (1962), and the resting pressures

and swallowing pressures reported by Winders (1962), are well within the range of pressures as recorded in this study.

A comparison of Tables 1 to 4 shows that means of pressures exerted against the teeth by the control group were greater than those of the study group. The higher inter-lip pressures exhibited by the study group are explained by Moyers, who states (1958):

With the mandible lowered, the lips must be forcibly closed to keep the tongue in the oral cavity. Therefore there is strong contraction of the mentalis muscle with all tongue thrusts during swallowing.

The low level of pressure exerted by the lips against the teeth at rest, reported by Kydd (1957) and Winders (1958, 1962), is supported in this study. The pressure, as recorded, of the lips at rest against the upper anterior teeth was slightly greater for the control group. The study group exerted slightly greater resting pressure against the lower teeth. This difference, however, is not statistically significant in magnitude. A slight difference in the resting pressure for a major portion of time could become an important contributing factor in the severe distocclusion associated with adverse swallowing.

At first thought, these findings would deny the thesis that adverse swallowing patterns with associated hyperactive mentalis function cause collapse of the lower incisors with concomitant gingival stripping. Occlusal and periodontal findings, however, are frequently associated with hyperactive mentalis muscle. The occlusal collapse and the gingival atrophy may be the result of loss of lingual support instead of increased labial pressures. This concept is suggested by Kydd (1957) in his attempt to equate the apparent imbalance of the musculature.



It appears that in a person with a "mentalis pattern," the direction of the force of the lip and the movement of the mass of the lip is in a vertical direction rather than a horizontal direction. It may be postulated that this frictional effect of vertical movement could help explain the periodontal findings.

It is felt that in the study group the lower lip exerted a pressure on the lingual surface of the maxillary incisor teeth during swallowing. This area was not included as a test site in this study, so its influence on the severe Class II malocclusion cannot be demonstrated.

This investigator hopes that future work will help to establish the amount of pressure exerted against the lingual surface of the maxillary incisor teeth by the lower lip during the acts of swallowing and speaking in individuals with a mentalis habit. This would further clarify the problem of pressure imbalances between lips and tongue in these persons.

There does not appear to be a difference between the two groups in the starting sequence of a recorded action. The upper and lower lips seemed to respond almost simultaneously to a command that requires the action of both lips. At the speed these records were taken, it is possible to compare time sequences to only approximately 1/20 of a second. It is possible that with records taken at faster speeds a time lag might be demonstrable. This requires more sophisticated technics.

Since all the individuals in the study group were recorded prior to the control group, it is possible that the control group could have received better instructions at the time of recording. This, however, is not considered to be of consequence, since all explanations and instructions were orientational, not repetitive, and therefore not conditional in nature.

It was noted that the pressure sensing cushions were sensitive to pressure changes during inspiration and expiration in all subjects. Since respiration was considered normal in all subjects, it was felt that this did not alter the validity of the records taken.

### CONCLUSIONS

This investigation has shown evidence that would point to the following conclusions:

1. The pressures exerted by the lips against the teeth and adjacent gum area of a person with a "normal" swallowing pattern are generally greater than those of persons showing an adverse swallowing pattern accompanied by a mentalis habit and Class II, Division I (Angle) malocclusion.

2. From this investigation the conclusion is drawn that the pressure resulting from the pull exerted by the mentalis and associated muscles is not primarily against the mandibular incisors and adjacent gum area.

3. There is an indication of a greater inter-lip pressure during swallowing of those with a mentalis habit, which is especially noted at the corners of the mouth.

4. There is a possibility that repetitive eversion of the lower lip in persons with a mentalis habit is contributory to the malocclusion frequently associated with it.

## CHAPTER VI

### SUMMARY

The forces exerted by the perioral musculature and the effects observed in subjects with adverse swallowing patterns accompanied by demonstrable mentalis habit were compared with a control group of "normal" subjects by the following methods:

1. Study casts were obtained for a morphological evaluation of dental structures.
2. Measurements of lip pressures were recorded via a hydraulically activated transducer system.

From the records accumulated, this investigation has shown evidences that point to the following:

1. Persons with a "normal" swallowing pattern generally exert greater pressures of lips against teeth and gums in both upper and lower arches during speaking and swallowing.
2. The pressures resulting from the pull exerted by the mentalis and associated muscles is not primarily against the mandibular incisors and adjacent gum area.
3. Persons with abnormal swallowing patterns accompanied by mentalis habit exert greater inter-lip pressures.
4. Since malocclusion is such a constant accompaniment of the mentalis habit, it is thought possible that the repetitive eversion of the lower lip associated with the mentalis habit may be contributory.

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**TABLES**

TABLE I

A summary of means and standard deviations of the maximum pressures observed for the control and study groups is presented. The unit of measurement is pounds per square inch. Greater pressures are recorded for the control group in six of the ten areas of measurement as follows:

|   |                                      |
|---|--------------------------------------|
| Drinking<br>Lower lip                         | Maximum effort pressure<br>Upper lip |
| Spontaneous swallow<br>Upper lip<br>Lower lip | Resting pressure<br>Upper lip        |
| Volitional swallow<br>Upper lip               |                                      |

The study group exhibited slightly greater pressures in the following four areas of measurement:

|                                 |                                      |
|---------------------------------|--------------------------------------|
| Drinking<br>Upper lip           | Maximum effort pressure<br>Lower lip |
| Volitional swallow<br>Lower lip | Resting pressure<br>Lower lip        |

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TABLE I  
SUMMARY OF MAXIMUM PRESSURES

| EXPERIMENTAL TASK       | CONTROL GROUP |                    | STUDY GROUP |                    |
|-------------------------|---------------|--------------------|-------------|--------------------|
|                         | MEAN          | STANDARD DEVIATION | MEAN        | STANDARD DEVIATION |
| Drinking                |               |                    |             |                    |
| Upper lip               | .19           | .08                | .22         | .23                |
| Lower lip               | .38           | .24                | .33         | .35                |
| Spontaneous swallow     |               |                    |             |                    |
| Upper lip               | .84           | .33                | .47         | .21                |
| Lower lip               | .79           | .32                | .61         | .31                |
| Volitional swallow      |               |                    |             |                    |
| Upper lip               | .91           | .36                | .55         | .35                |
| Lower lip               | .73           | .56                | .82         | .42                |
| Maximum effort pressure |               |                    |             |                    |
| Upper lip               | 2.27          | .82                | 1.39        | .48                |
| Lower lip               | 1.29          | .67                | 1.31        | .58                |
| Resting pressure        |               |                    |             |                    |
| Upper lip               | .09           | .06                | .08         | .06                |
| Lower lip               | .05           | .01                | .08         | .06                |
| Number of cases         | 6             |                    | 11          |                    |

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**TABLE II**

A summary of means and standard deviations of maximum pressures during speech sounds are given for the control and study groups. Greater measurements of pressures are recorded for the control group in all areas for all speech sounds. The unit of measurement is pounds per square inch.

**TABLE II**  
**SUMMARY OF MAXIMUM PRESSURES DURING SPEECH**

| EXPERIMENTAL TASK          | CONTROL GROUP |                    | STUDY GROUP |                    |
|----------------------------|---------------|--------------------|-------------|--------------------|
|                            | MEAN          | STANDARD DEVIATION | MEAN        | STANDARD DEVIATION |
| Word #1 "Puppy"            |               |                    |             |                    |
| Upper lip                  | 1.29          | .35                | .82         | .36                |
| Lower lip                  | .68           | .31                | .66         | .22                |
| Word #2 "Firefly"          |               |                    |             |                    |
| Upper lip                  | .51           | .36                | .17         | .17                |
| Lower lip                  | 1.03          | .22                | .58         | .21                |
| Word #3 "Thick toothbrush" |               |                    |             |                    |
| Upper lip                  | .99           | .18                | .49         | .30                |
| Lower lip                  | .75           | .28                | .51         | .19                |
| Number of cases            | 6             |                    | 11          |                    |



### TABLE III

A summary of means and standard deviations of forces exerted is given for the control and study groups. Relating the sum of pressures to a time base, measurements were computed for spontaneous swallowing and for speech sounds. The control group exerted greater pressures than the study group with but one exception--speech sound "thick toothbrush" as recorded for the upper lip. This pressure was only slightly greater. The unit of measurement for forces exerted is pounds per square inch per second.

**TABLE III**  
**SUMMARY OF FORCES EXERTED\***

| EXPERIMENTAL TASK          | CONTROL GROUP |                    | STUDY GROUP |                    |
|----------------------------|---------------|--------------------|-------------|--------------------|
|                            | MEAN          | STANDARD DEVIATION | MEAN        | STANDARD DEVIATION |
| Spontaneous swallow        |               |                    |             |                    |
| Upper lip                  | 5.11          | 2.03               | 2.51        | 1.06               |
| Lower lip                  | 3.93          | 1.19               | 2.96        | 1.37               |
| Word #1 "Puppy"            |               |                    |             |                    |
| Upper lip                  | 5.02          | 1.59               | 2.82        | 1.91               |
| Lower lip                  | 2.66          | 1.44               | 2.02        | .74                |
| Word #2 "Firefly"          |               |                    |             |                    |
| Upper lip                  | 1.49          | .27                | .66         | .54                |
| Lower lip                  | 3.33          | .66                | 1.56        | .79                |
| Word #3 "Thick toothbrush" |               |                    |             |                    |
| Upper lip                  | 1.52          | .30                | 1.71        | 2.69               |
| Lower lip                  | 1.45          | .36                | 1.12        | .55                |
| Number of cases            | 6             |                    | 11          |                    |

\*Forces exerted are expressed in pounds per square inch per second.

TABLE IV

A summary of the means and standard deviations for between-lip measurements is given for the study and control groups. These pressures were recorded at the center and corner of the mouth during a volitional swallow and for maximum effort. The study group exerted greater pressures for all tests in all areas of between-lip pressures. The unit of measurement is pounds per square inch.

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**TABLE IV**  
**SUMMARY OF BETWEEN-LIP PRESSURES**

| EXPERIMENTAL TASK  | CONTROL GROUP |                    | STUDY GROUP |                    |
|--------------------|---------------|--------------------|-------------|--------------------|
|                    | MEAN          | STANDARD DEVIATION | MEAN        | STANDARD DEVIATION |
| Maximum pressures  |               |                    |             |                    |
| Center of mouth    | 1.18          | .57                | 1.48        | .57                |
| Corner of mouth    | .50           | .43                | 1.29        | .35                |
| Volitional swallow |               |                    |             |                    |
| Center of mouth    | .36           | .24                | .53         | .24                |
| Corner of mouth    | .27           | .19                | .73         | .35                |
| Number of cases    | 6             |                    | 10          |                    |

#### TABLE V

A summary of the difference of means, of the standard error of the difference, and of t values is given for maximum pressures. The statistics presented in this table represent the analyses of the statistics found in Table I. The t values which are significant at the 5 per cent level are for spontaneous swallow, upper lip; and maximum pressure, upper lip.

TABLE V

SUMMARY OF DIFFERENCE OF MEANS AND t VALUES FOR MAXIMUM PRESSURES

| EXPERIMENTAL TASK   | DIFFERENCE OF MEANS | STANDARD ERROR OF THE DIFFERENCE | t VALUE |
|---------------------|---------------------|----------------------------------|---------|
| Drinking            |                     |                                  |         |
| Upper lip           | .03                 | .076                             | .52     |
| Lower lip           | .05                 | .145                             | .35     |
| Spontaneous swallow |                     |                                  |         |
| Upper lip           | .37                 | .148                             | 2.50*   |
| Lower lip           | .18                 | .158                             | 1.14    |
| Volitional swallow  |                     |                                  |         |
| Upper lip           | .36                 | .181                             | 1.99    |
| Lower lip           | -.09                | .261                             | .35     |
| Maximum pressure    |                     |                                  |         |
| Upper lip           | .88                 | .363                             | 2.42*   |
| Lower lip           | -.02                | .317                             | .63     |
| Resting Pressure    |                     |                                  |         |
| Upper lip           | .01                 | .035                             | .29     |
| Lower lip           | -.03                | .025                             | 1.22    |

\*t Value of significance at 5 per cent level.

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**TABLE VI**

A summary of the differences of means, of the standard error of the difference, and of  $t$  values is given for speech sounds. The statistics presented in this table represent the analyses of the statistics found in Table II. The  $t$  values which are significant at the 5 per cent level are: word no. 1 "puppy," upper lip; word no. 2 "firefly," upper lip.

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TABLE VI

SUMMARY OF DIFFERENCE OF MEANS OF PRESSURES  
AND t VALUES FOR SPEECH SOUNDS

| EXPERIMENTAL TASK             | DIFFERENCE OF MEANS | STANDARD ERROR OF THE DIFFERENCE | t VALUE |
|-------------------------------|---------------------|----------------------------------|---------|
| Word No. 1 "Puppy"            |                     |                                  |         |
| Upper lip                     | .47                 | .179                             | 2.62*   |
| Lower lip                     | .02                 | .142                             | 1.55    |
| Word No. 2 "Firefly"          |                     |                                  |         |
| Upper lip                     | .34                 | .152                             | 2.18*   |
| Lower lip                     | .45                 | .346                             | 1.30    |
| Word No. 3 "Thick toothbrush" |                     |                                  |         |
| Upper lip                     | .50                 | .368                             | 1.36    |
| Lower lip                     | .24                 | .577                             | .42     |

\*t Value of significance at 5 per cent level.



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TABLE VII

A summary of the differences of means, of the standard error of the difference, and of t values is given for forces exerted. The statistics presented in this table represent the analyses of the statistics found in Table III. The t values which are significant at the 5 per cent level are: spontaneous swallow, upper lip; word no. 1 "puppy," upper lip. The t values which are significant at the 1 per cent level are: word no. 2 "firefly," upper lip and lower lip.

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TABLE VII

SUMMARY OF DIFFERENCE OF MEANS AND t VALUES FOR FORCES EXERTED#

| EXPERIMENTAL TASK             | DIFFERENCE OF MEANS | STANDARD ERROR OF THE DIFFERENCE | t VALUE |
|-------------------------------|---------------------|----------------------------------|---------|
| Spontaneous swallow           |                     |                                  |         |
| Upper lip                     | 2.60                | .895                             | 2.91*   |
| Lower lip                     | .97                 | .646                             | 1.50    |
| Word No. 1 "Puppy"            |                     |                                  |         |
| Upper lip                     | 2.20                | .869                             | 2.54*   |
| Lower lip                     | .64                 | .596                             | 1.24    |
| Word No. 2 "Firefly"          |                     |                                  |         |
| Upper lip                     | .83                 | .196                             | 4.23**  |
| Lower lip                     | 1.77                | .344                             | 5.15**  |
| Word No. 3 "Thick toothbrush" |                     |                                  |         |
| Upper lip                     | -.19                | .819                             | .23     |
| Lower lip                     | .33                 | .688                             | .48     |

\*t Value of significance at 5 per cent level.

\*\*t Value of significance at 1 per cent level.

#Forces exerted are expressed in pounds per square inch per second.

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**TABLE VIII**

A summary of the difference of means, of the standard error of the difference, and of t values is given for between-lip pressures. The statistics presented in this table represent the analyses of the statistics found in Table IV. The t value which is significant at the 5 per cent level is maximum pressure, corner of mouth. Significant at the 1 per cent level is volitional swallow, corner of mouth.

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TABLE VIII  
 SUMMARY OF DIFFERENCE OF MEANS AND t VALUES FOR BETWEEN-LIP PRESSURES

| EXPERIMENTAL TASK  | DIFFERENCE OF MEANS | STANDARD ERROR OF THE DIFFERENCE | t VALUE |
|--------------------|---------------------|----------------------------------|---------|
| Maximum pressures  |                     |                                  |         |
| Center of mouth    | -.30                | .293                             | 1.02    |
| Corner of mouth    | -.79                | .278                             | 2.84*   |
| Volitional Swallow |                     |                                  |         |
| Center of mouth    | -.17                | .123                             | 1.38    |
| Corner of mouth    | -.46                | .134                             | 3.43**  |

\*t Value of significance at 5 per cent level.  
 \*\*t Value of significance at 1 per cent level.

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**ILLUSTRATIONS**

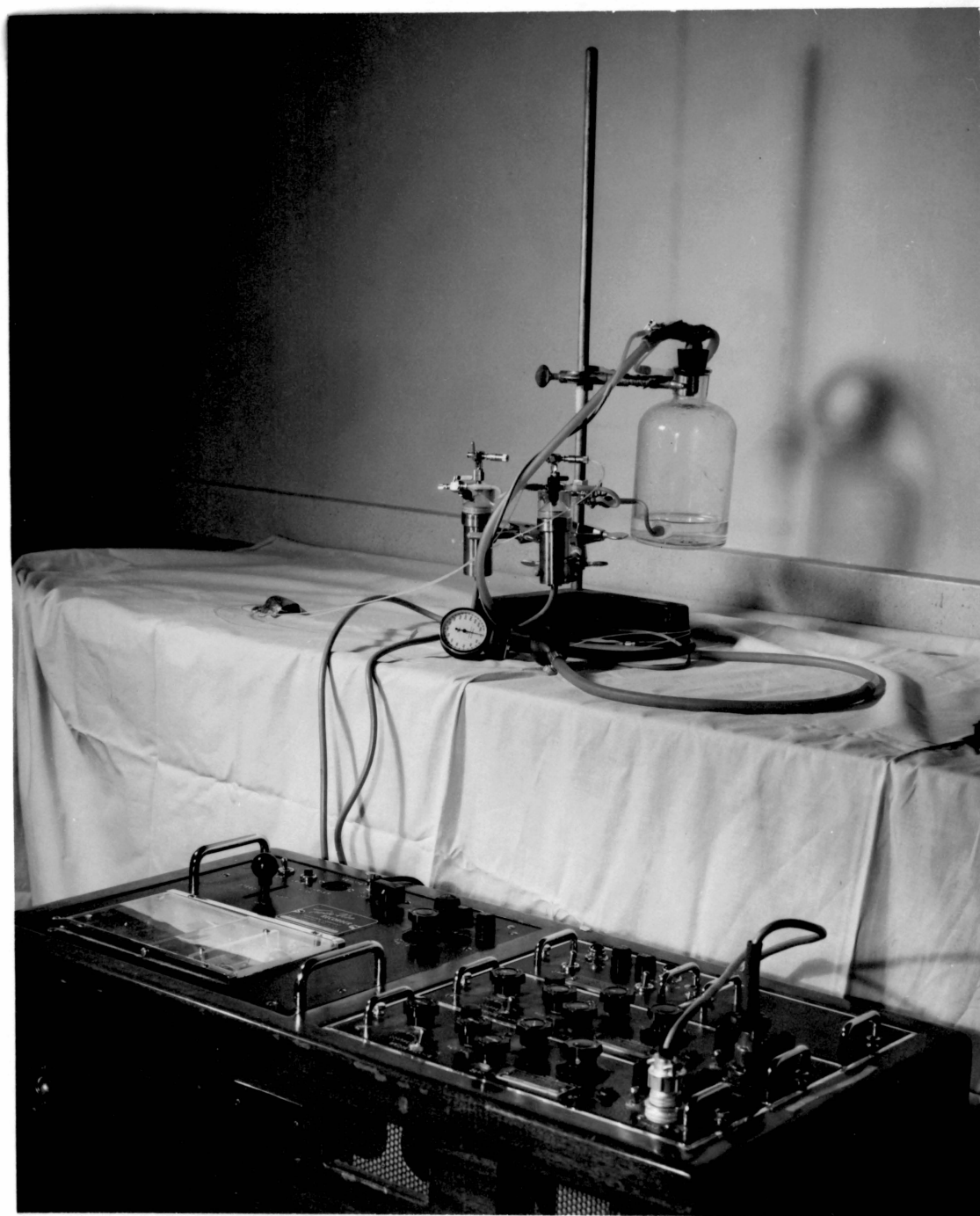


ILLUSTRATION 1

SANBORN TWIN-VISO RECORDER EQUIPPED WITH  
STRAIN GAUGE AMPLIFIERS AND TRANSDUCERS

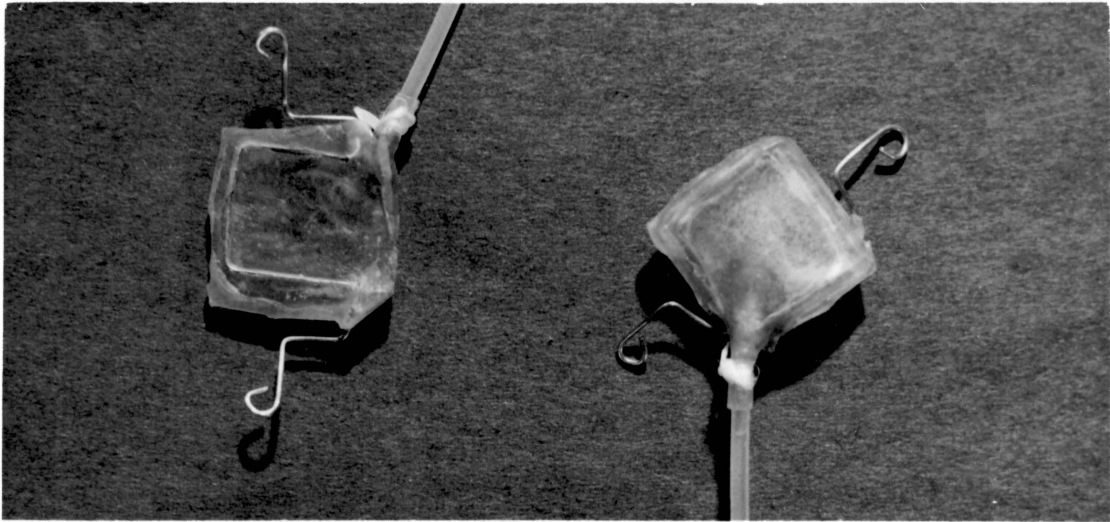


ILLUSTRATION 2

PRESSURE SENSING CUSHIONS

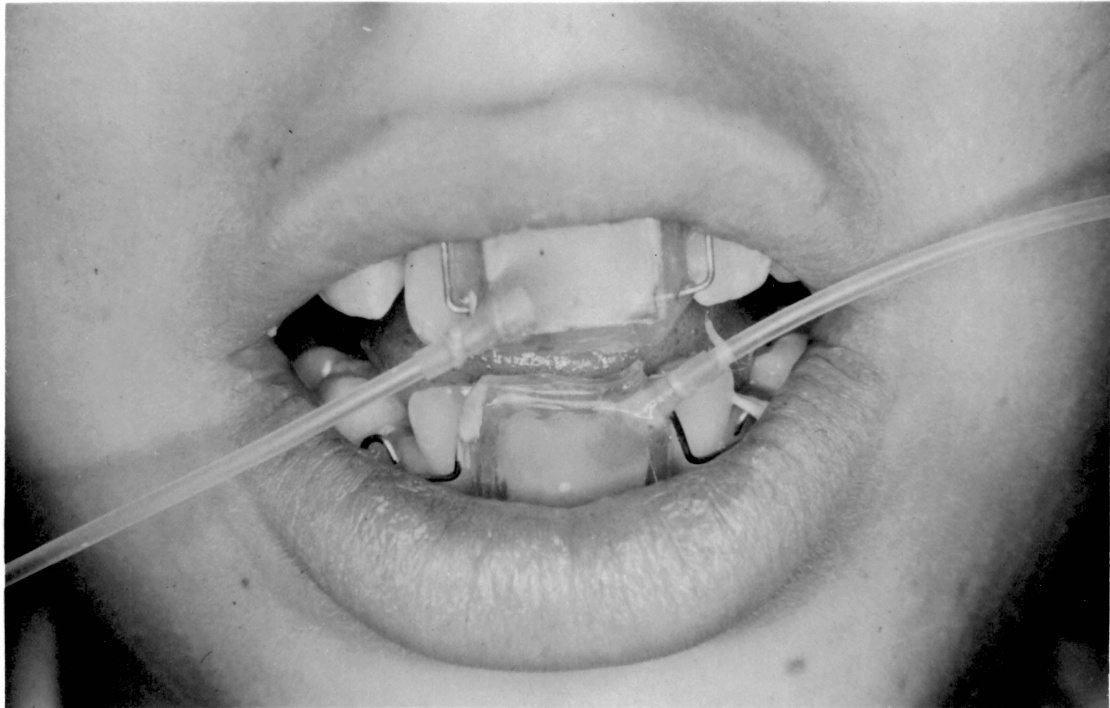


ILLUSTRATION 3

PRESSURE SENSING CUSHIONS IN PLACE

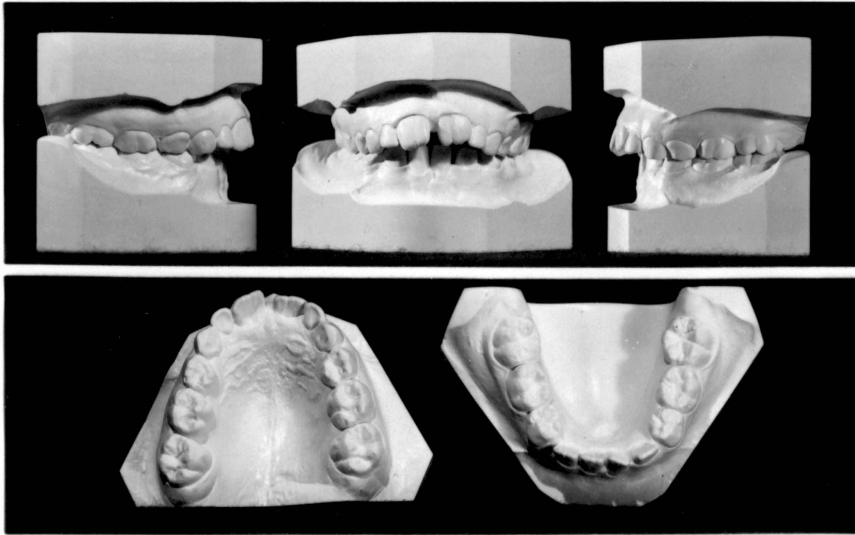


ILLUSTRATION 4

STUDY CASTS  
REPRESENTATIVE CASTS FROM STUDY GROUP  
SUBJECT E.J.

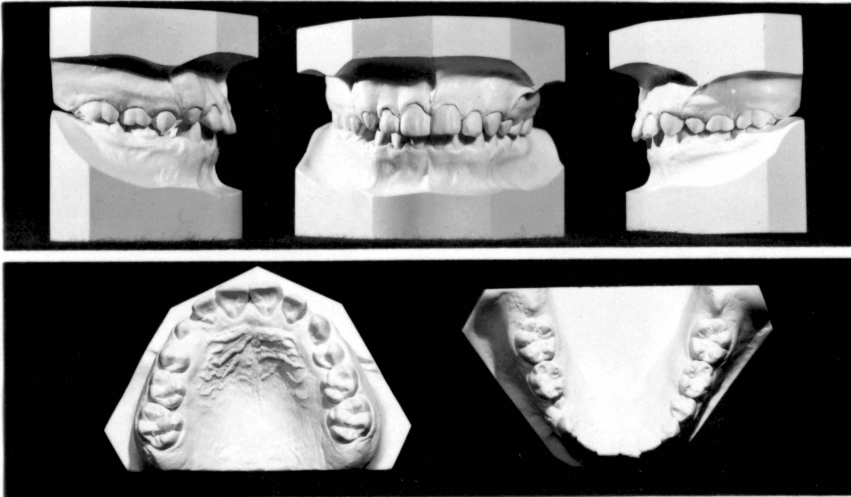


ILLUSTRATION 5

STUDY CASTS  
REPRESENTATIVE CASTS FROM CONTROL GROUP  
SUBJECT C.M.



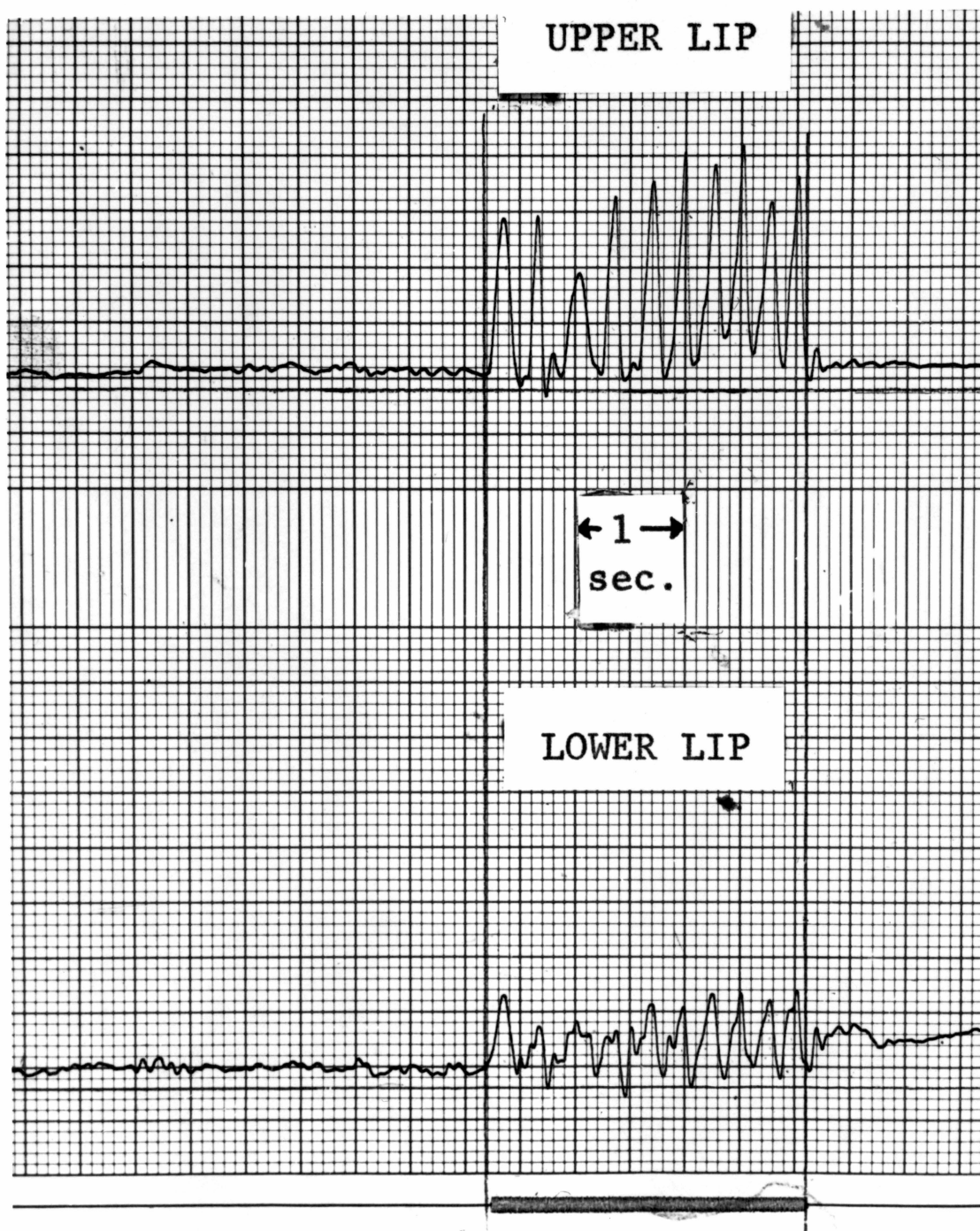


ILLUSTRATION 6

PRESSURE RECORDINGS, CONTROL SUBJECT L.W.  
SPEECH SOUND "PUPPY" REPEATED 5 TIMES, 25 mm. DEFLECTION = 1 psi  
RECORDING SPEED 10 mm./sec.

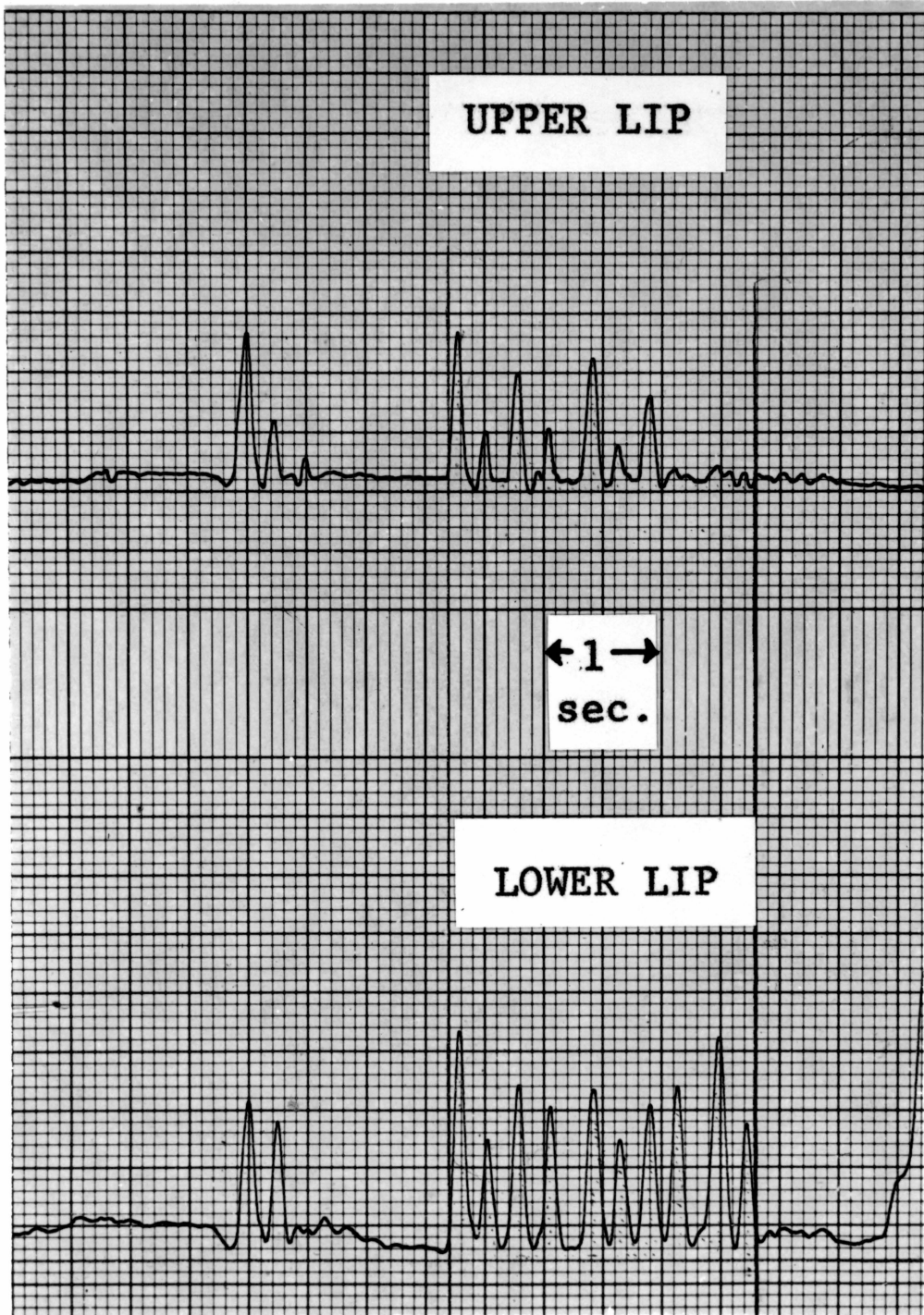


ILLUSTRATION 7

PRESSURE RECORDINGS, STUDY SUBJECT D.H.  
SPEECH SOUND "PUPPY" REPEATED 5 TIMES, 25 mm. DEFLECTION = 1 psi  
RECORDING SPEED 10 mm./sec.

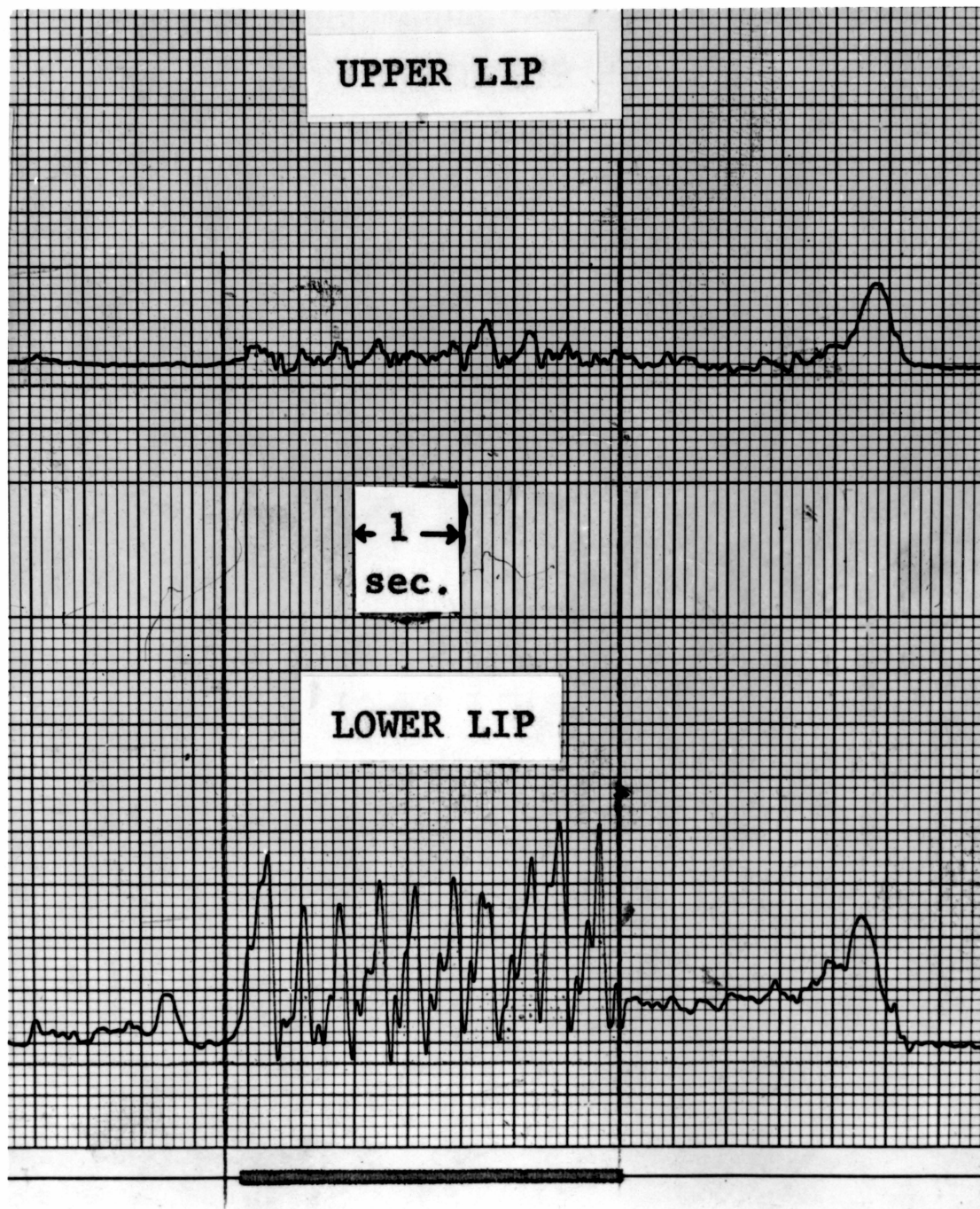


ILLUSTRATION 8

PRESSURE RECORDINGS, CONTROL SUBJECT L.W.  
SPEECH SOUND "FIREFLY" REPEATED 5 TIMES, 25 mm. DEFLECTION = 1 psi  
RECORDING SPEED 10 mm./sec.

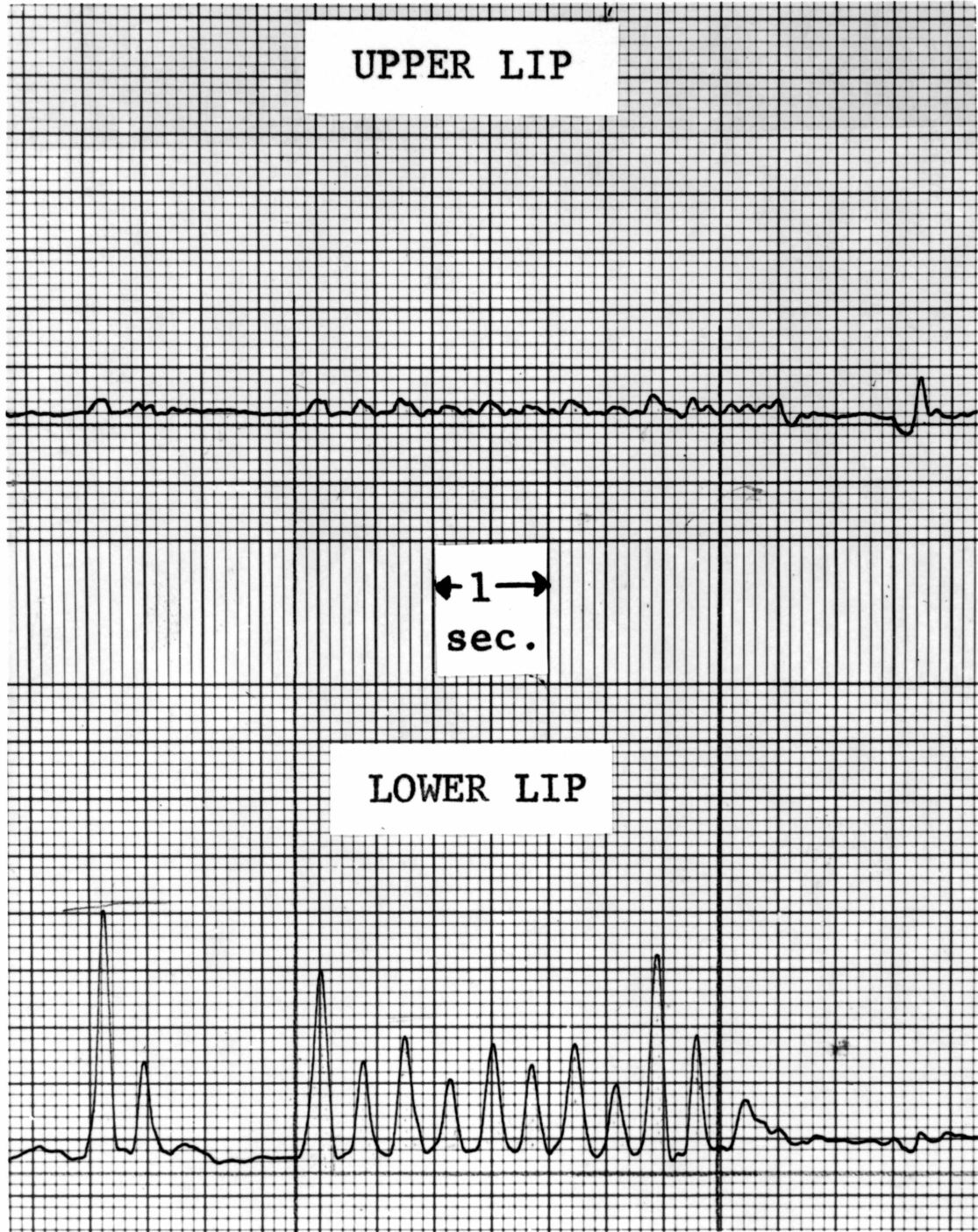


ILLUSTRATION 9

PRESSURE RECORDINGS, STUDY SUBJECT D.H.  
SPEECH SOUND "FIREFLY" REPEATED 5 TIMES, 25 mm. DEFLECTION = 1 psi  
RECORDING SPEED 10 mm./sec.

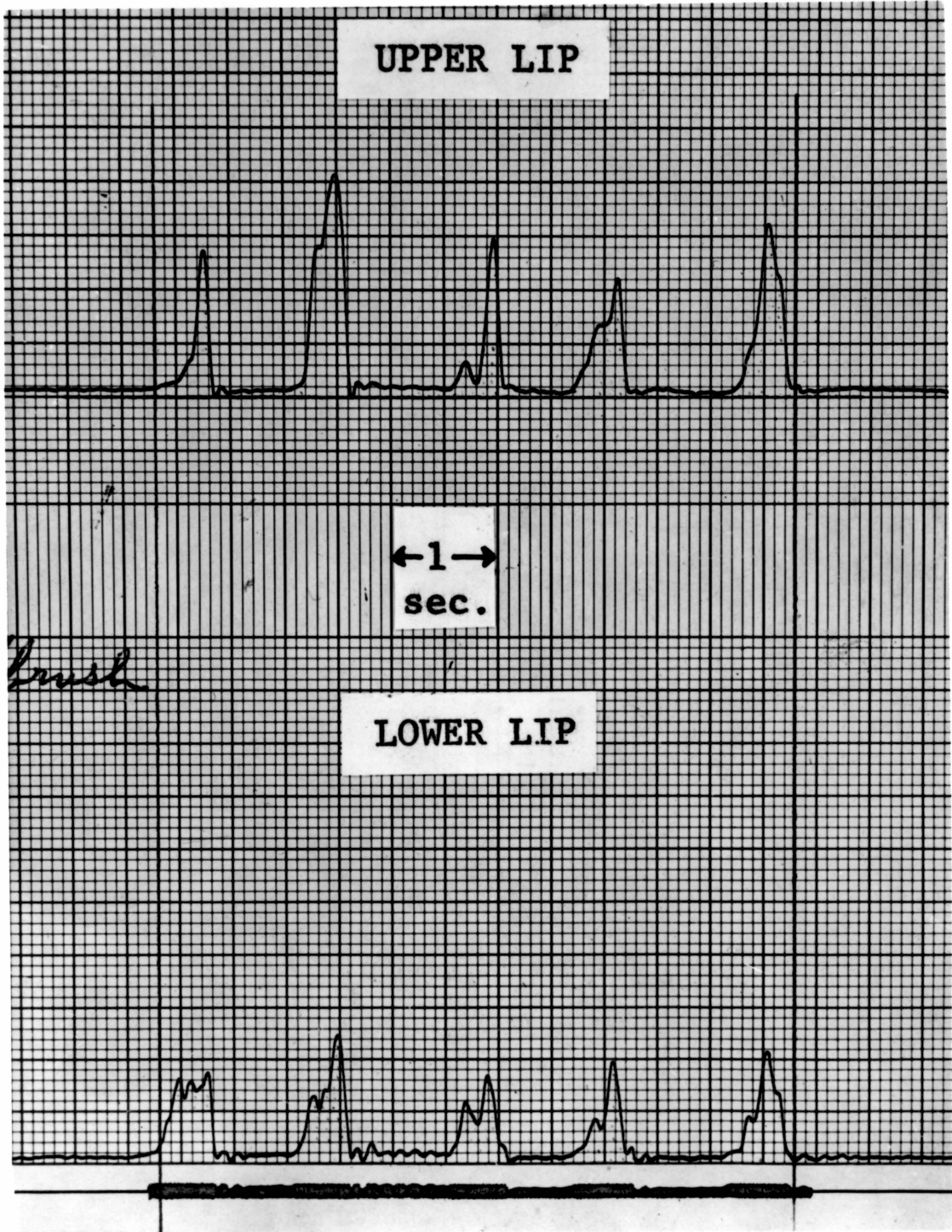


ILLUSTRATION 10

PRESSURE RECORDINGS, CONTROL SUBJECT H.M.  
 SPEECH SOUND "THICK TOOTHBRUSH" REPEATED 5 TIMES,  
 25 mm. DEFLECTION = 1 psi. RECORDING SPEED 10 mm./sec.

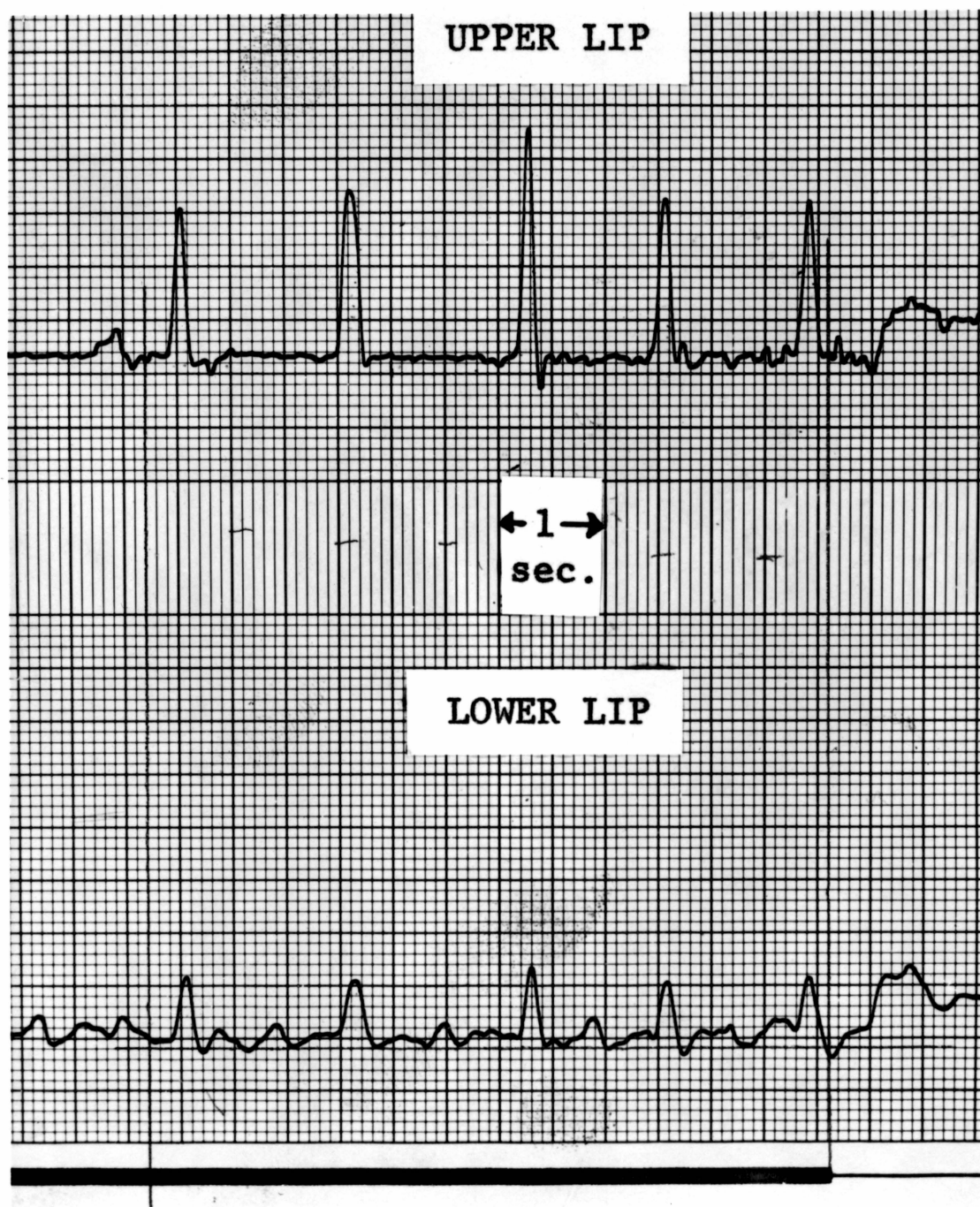


ILLUSTRATION 11

PRESSURE RECORDINGS, STUDY SUBJECT E.J.  
SPEECH SOUND "THICK TOOTHBRUSH" REPEATED 5 TIMES,  
20 mm. DEFLECTION = 1 psi. RECORDING SPEED 10 mm./sec.

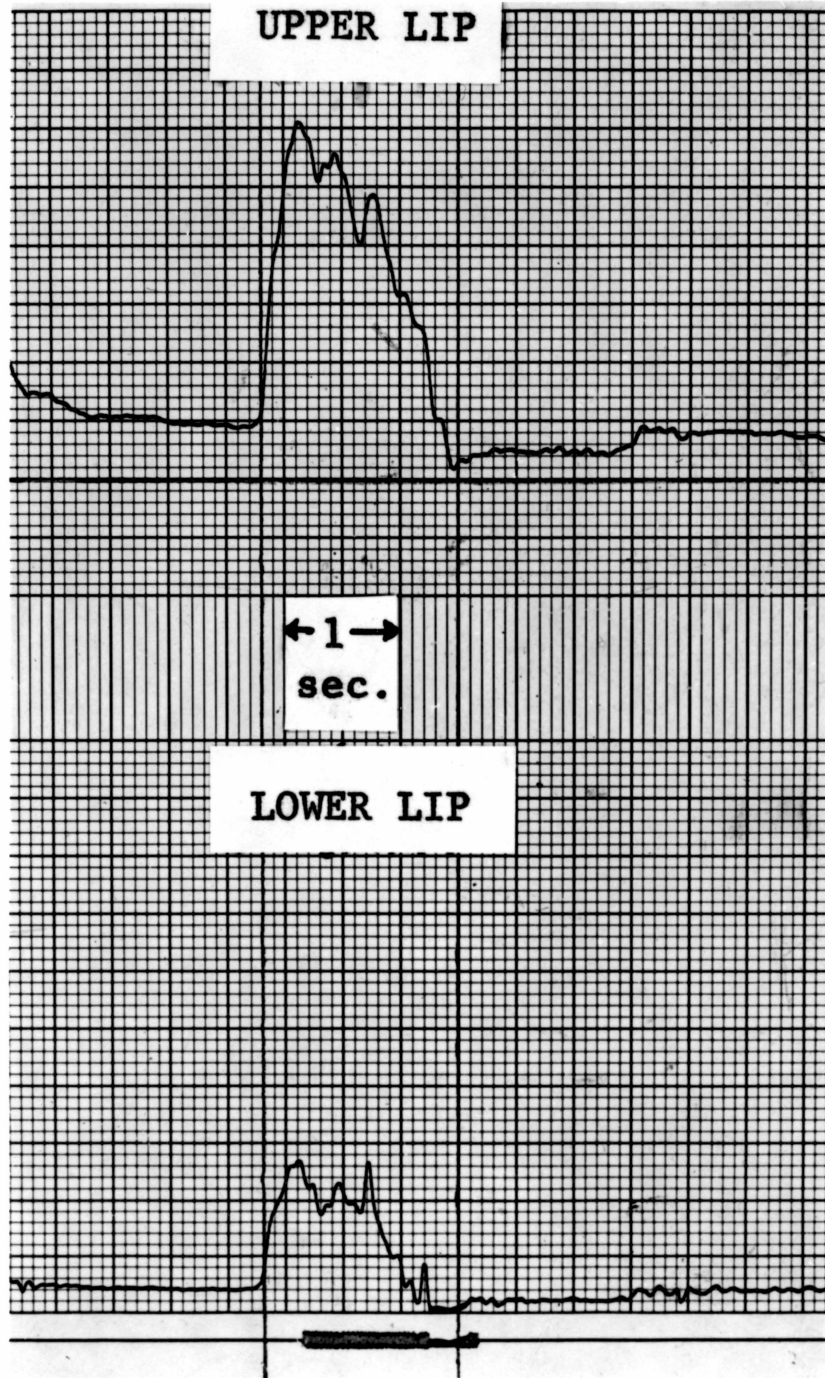


ILLUSTRATION 12

PRESSURE RECORDINGS, CONTROL SUBJECT H.M.  
VOLITIONAL SWALLOW 25 mm. DEFLECTION = 1 psi  
RECORDING SPEED 10 mm./sec.

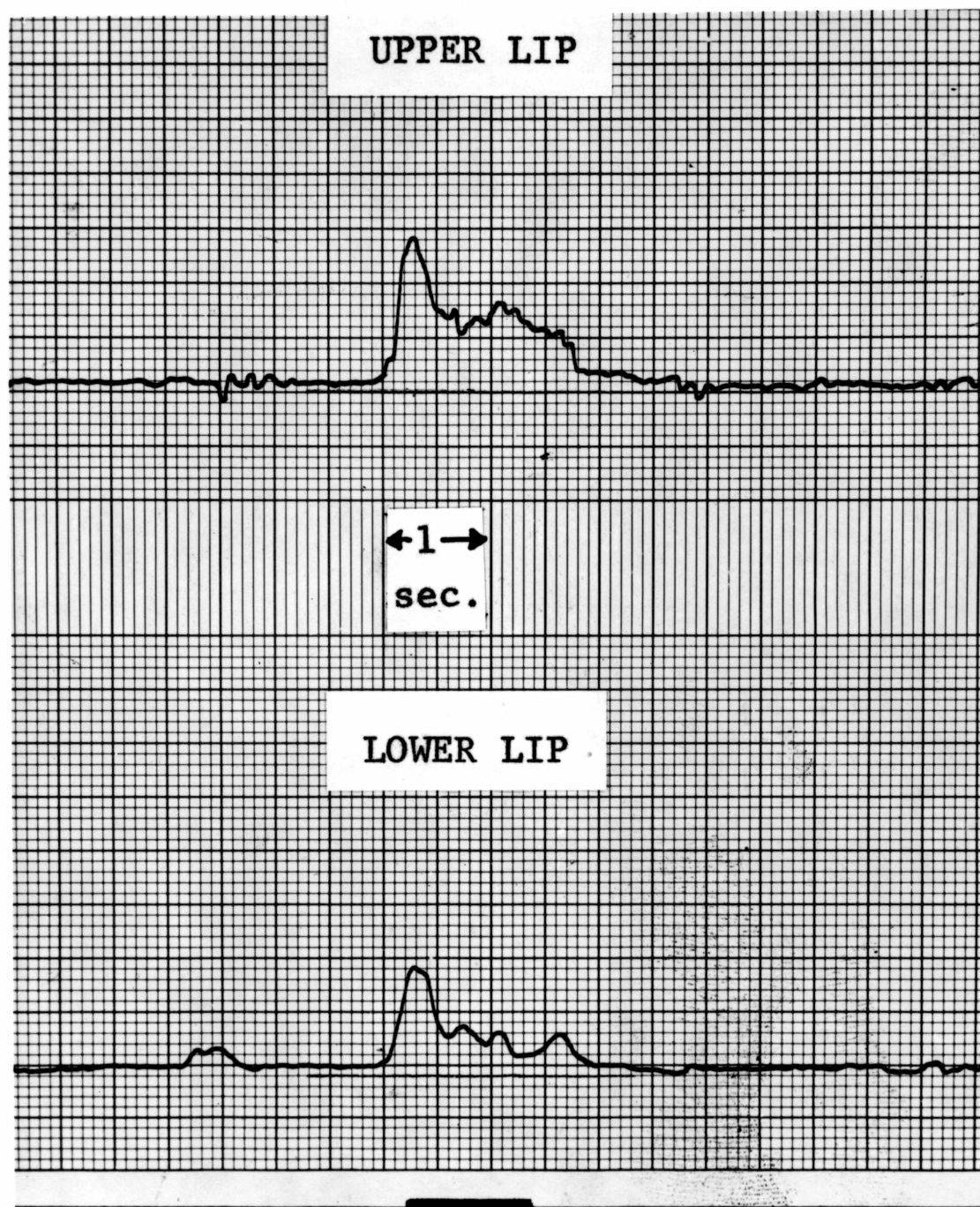


ILLUSTRATION 13

PRESSURE RECORDINGS, STUDY SUBJECT E.J.  
VOLITIONAL SWALLOW 20 mm. DEFLECTION = 1 psi  
RECORDING SPEED 10 mm./sec.



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A MYOMETRIC EVALUATION OF CERTAIN ASPECTS OF THE  
PERIOPAL MUSCULATURE IN INDIVIDUALS WITH  
DEMONSTRABLE ADVERSE SWALLOWING PATTERNS

by

John Milford Anholm

An Abstract of a Thesis  
in Partial Fulfillment of the Requirements  
for the Degree Master of Science  
in the Field of Orthodontics

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## ABSTRACT

The forces exerted by the perioral musculature and the effects observed in subjects with adverse swallowing patterns accompanied by demonstrable mentalis habits were compared with a control group of "normal" subjects by the following methods:

1. Study casts of upper and lower arches were obtained for a morphological evaluation of dental structures.
2. Measurements of lip pressures against the teeth were recorded for the following:
  - a. Drinking water
  - b. Volitional and spontaneous swallows
  - c. Designated speech sounds
  - d. Maximum effort pressures
3. Measurements of inter-lip pressures were recorded at the center and corner of the mouth for the following:
  - a. Maximum pressures
  - b. Volitional swallow

The recording instrument consisted of a cast rubber pressure sensing cushion coupled to a pressure-sensitive transducer by small, relatively inelastic tubing. The system was hydraulically activated. The signals from the transducer were recorded by a two-channel recorder equipped with strain gauge amplifiers.

From the records accumulated, this investigation has shown evidences that point to the following:

1. Persons with a "normal" swallowing pattern generally exert greater pressures of lips against teeth and gums in both upper and lower arches during speaking and swallowing.

2. The pressures resulting from the pull exerted by the mentalis and associated muscles is not primarily against the mandibular incisors and adjacent gum area.

3. Persons with abnormal swallowing patterns accompanied by mentalis habit exert greater inter-lip pressures.

4. Since malocclusion is such a constant accompaniment of the mentalis habit, it is thought possible that the repetitive eversion of the lower lip associated with the mentalis habit may be contributory.

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