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A study of bilabial lip pressure in a normal population

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Abstract

Values for bilabial lip pressure on 1,417 children ranging in age from 5 to 18 years of age are presented. The use of bilabial lip pressure values as a tool in monitoring speech production of children with neuromuscular disease, articulation disorders and cleft lip is discussed. Variations with age, sex, height, weight and malocclusion type are presented with mean average values being 5 to 20% larger than the maximum recordings.

In males, the mean values rose by approximately 5% between the ages of 5 and 7 years, remained fairly constant up to age 11, between 11 and 14 years the mean values more than trebled after which they gradually declined with males aged 18 and over having a mean of approximately 75% of the peak at 14 years. In females, the mean values were similar to males up to age 11 years and also demonstrated a sharp increase thereafter peaking at 14 years. The peak for females was, however, only 60% of the corresponding male value, having doubled in the 11-14 year period in contrast to the males who showed a three fold increase. Females exhibited a decline in mean values afte 14 years of a similar relative magnitude to that of the males.

Correlation with height and weight are presented but regression analysis showed that these factors had little additional influence over and above those of subject age.

Key Words: Bilabial lip pressure, cross sectional measurements, adolescent changes

INTRODUCTION

Researchers in the fields of orthodontics and speech have long been interested in the measurement of lip pressure.

Orthodontics

For orthodontics, such measurements have been utilized to assess to what extent tooth position and arch formation are influenced by pressures from lip, cheeks and tongue.

Early researchers in orthondontics relied on small balloons for pressure sensors, and similar methods prevailed until the fifties. More recently, techniques and equipment of electronic pressure sensing devices with electronic amplification systems and recorders, allowed pressure measurements to approach the necessary sensitivity and accuracy. Winders (1956/58) utilized wire strain gauge resistance transducers, with a suitable amplifier/recorder, in which a mouthpiece was secured to the teeth.

Jacobs and Brody (1966) used a strain gauge measuring device to measure oral vestibular forces acting upon 'normal' human denture, and Gould & Picton (1962/63/68) evaluated foil strain gauges to measure lip and cheek pressure on the teeth.

Luffingham (1968a/68b/69a/69b) investigated lip and cheek pressure exerted on teeth and outlined some of the relevant technical problems. Schopf (1971) reported in detail on the construction, action and calibration of similar instrumentation for measurement. Proffitt (1975) utilized data, collected by miniaturized foil gauges with portable amplifiers and recorders, on Central Australian aborigines to compare their tongue and lip activity with that of North American whites. Proffitt (1978) also described a very thin occlusal force transducer based on piezoelectric film.

Research has been primarily directed to questions of tongue, lip and cheek pressure on teeth, and superior/inferior bilabial pressure, has not been recorded.

Speech Therapy

In the field of speech research, developments have followed a more or less similar pattern. Early investigators employed tambours to transduce the speech movements of jaws and lips (Hudgins, 1934). Photographic (Fujimura, 1961) and photoconductive (Ohala, et. al., 1968) techniques were later adopted. A flurry of research followed the development of electromagnetic and strain gauge pressure transducer devices. Researchers, armed with a tool which more closely met their measurement needs, embarked on various programmes involving the measurement of speech movements (Harris, Lysaught and Schvey, 1965; Fromkin, 1966; Sussmann and Smith, 1970; Tattham and Morton, 1970, 1973; Lubker and Parris, 1970; Abbs, 1973, Abbs and Gilbert, 1973; McClean, 1978; Muller and Abbs, 1979). Generally these researchers were involved in the measurement of labial pressure as one aspect only of more general measurements of speech activities of lips, tongue and jaw. For this component they generally used strain gauge resistance transducers, either placed directly on the lower lip or with a lip contact portion adhering to the lips, or, as described by Sussman and Smith (1970) with the transducers mounted externally to the subject necessitating cephalostat head stabilization to prevent extraneous movements of the head for simultaneous observation of the complex movements of upper and lower lip and jaw motion. A computer controlled x-ray technique has also been developed to provide time-motion signals of tongue, jaw, lips and velum (Fujimura, Kiritani and Ishida, 1973).

Baskerville, (1977) recorded the orbicularis oris muscular strength for 114 grade three to six children by recording the amount of pressure necessary to remove a button inserted in the labial vestibule. Lubker and Parris (1969) comment on the variability in bilabial pressure recordings and investigated simultaneous measures of various pressures exerted during production of bilabial consonants. They noticed considerable between subjects variability and underscored "the need for caution when making assumptions based on such data, especially if only a limited number of subjects are used in the experiment".

MATERIALS & METHODS

Apparatus

As the study was concerned only with superior/inferior (vertical) bilabial pressure, a simple open-end or U-tube manometer (Figure 1) was utilized. The U-tube was filled with food dye and detergent. One end was open to the atmosphere and the other end attached to a slightly flexible rubber hose which had a metal tube with a pressure release bulb inserted in the service end, to which was affixed a firm rubber Ansell eye-dropper bulb. The atmosphere exerts pressure on the open end, the bilabial pressure of the subject on the other end. When the pressure in the system is equal to the atmospheric pressure, the heights of the liquids are the same. When there is a difference in the level of the liquid, it is a measure of the difference in pressure. The manometer scale has a peak-hold reading system whereby the pressure reading is frozen at peak for ease and accuracy of recording.

This instrument had the advantages of stability and portability as a field instrument and its accuracy was considered appropriate for the requirements of this study. An excellent description of U-tube manometers is given in Chemical Technicians' Reading Reference Handbook, Sheyar et. al, 1981.

Subjects

1,417 subjects from a Brisbane state primary and secondary school in grades 1 to 12 inclusive represented the sample. The subjects ranged in age from 5 to 18+ years of age, and comprised 678 females and 739 males.

Method

Each class was given group instructions and demonstrations prior to testing of the individual members.

They were asked to "put your teeth together, lips apart and then press as tightly as possible in a smooth movement until a maximum pressure is exerted." The bulb was located centrally between the lips.

Each subject was tested with four separate performances of each given task, and each result was recorded with the age, weight, height and sex of the subject. As well, malocclusions based on Angle's classification system were noted. Class II Division I type incisor malocclusions based on Class I molar base were recorded separately from Class I, II or III malocclusions. A further notation was made for those subjects in the process of orthondontic treatment for malocclusion.

RESULTS

The 1,417 subjects were divided into three classes prior to analysis: —

(i) children without malocclusion (540 males and 437 females),

(ii) children with untreated malocclusions (178 males and 208 females), and

(iii) children undergoing treatment for their malocclusions (34 subjects).

Analyses were done separately for the first two classes and for each sex. The small third group was not analysed at all. Most analyses were done after further dividing the children into peer groups of the same age, in years. Table 1 shows the number of children in each of these groups. The results which follow pertain only to the children without obvious maloclussion. A further study investigating lip pressure in the malocclusal group will be reported in a subsequent paper.

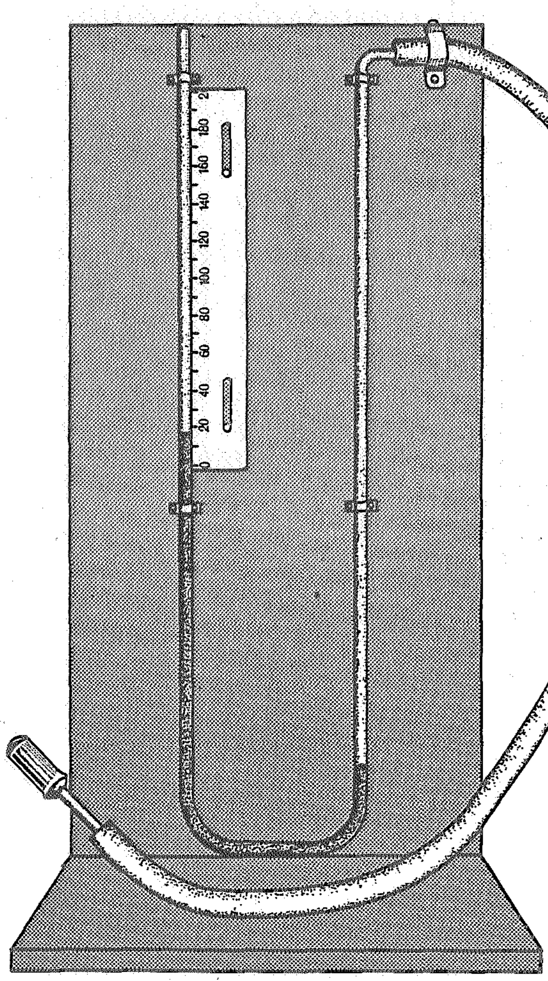

Figure 1 — The Oral Monometer

TABLE 1 Number of subjects by year of age, sex and with or without malocclusion

	No malocclusion		With malocclusion	
(years)	Males	Females	Males	Females
5	8	4	1	0
6	28	36	11	8
7	30	15	11	15
8	28	28	18	20
9	26	19	9	26
10	36	25	21	33
11	50	25	20	27
12	49	36	22	21
13	71	57	22	21
14	62	64	16	9
15	65	50	12	17
16	46	40	8	17
17	25	32	6	8
18+	16	9	1	3

Repeatability of Measurements

This was done by estimating the ratio of the between subject component of variance and within subject variance for all peer groups. This ratio varied from a minimum value of 4.5 to a maximum of nearly 20.0 across the different age and sex classes, indicating that these lip pressure movements showed much less variation within subjects than between subjects (Table 2). There was a slight predominance of high variance component ratios in the age groups 7 years to 9 years, suggesting less relative variation within subjects of these ages than at other age groups. This may have been due to the higher proportion of children of these ages who failed to register any non-zero readings in their four recordings.

TABLE 2 Ratio of between subject component of variance to within subject component of variance by age group and sex

Age	No malocclusion	
(year)	Males	Females
6	5.09	5.51
7	11.30	13.65
8	10.21	7.14
9	14.92	19.09
10	7.13	5.79
11	4.50	7.79
12	7.88	6.47
13	8.03	5.11
14	5.04	4.15
15	17.07	9.43
16	5.92	5.06
17	6.55	5.60
18+	8.55	6.82

Effects of Chronological Age on Average Lip Pressure Recordings

The four recordings for each child were summarized as a single measure in two ways: by their average value and by their maximum value (Figure 2). Means and standard deviations for each peer group were calculated for both these summary statistics. The standard deviations of the distributions of maximum values were usually slightly larger than the corresponding figures for the distribution of the averages of the four recordings. Thus the averages were the more precise summary measure. In addition, maximum values always closely followed the means, being 5% to 20% larger, for all age and sex classes. Only the means were subject to further investigation.

The mean values of the averages and 95% confidence intervals for males and females and for different ages are shown in Figure 2. In males, the mean values rose by about 50% between the ages of 5 to 7. Mean lip pressure was then fairly constant up to age 11. Between this age and 14 years, mean values more than tripled, after which a gradual decline in mean values occurred with males aged 18 or more having a mean value of roughly 75% of the peak at 14 years.

In females, mean values were similar to males up to the age of 11, after which a sharp increase occurred with a peak at 14 years, as occurred for males. In contrast to the male's more than three times increase, the females increase from age 11 to 14 years was little more than a doubling. The peak in the female mean values at age 14 years was, as a consequence, only 60% of the corresponding male values. In females over 14 years, a decline in mean values occurred which was of a similar relative magnitude to that which occurred in males.

Sex and age differences between mean lip pressure recordings are clearly seen in figure 3, which shows 95% confidence intervals for mean lip pressure for each sex and age class. Note that up to 14 years of age confidence intervals for the sex areas overlap considerably, but not in older children.

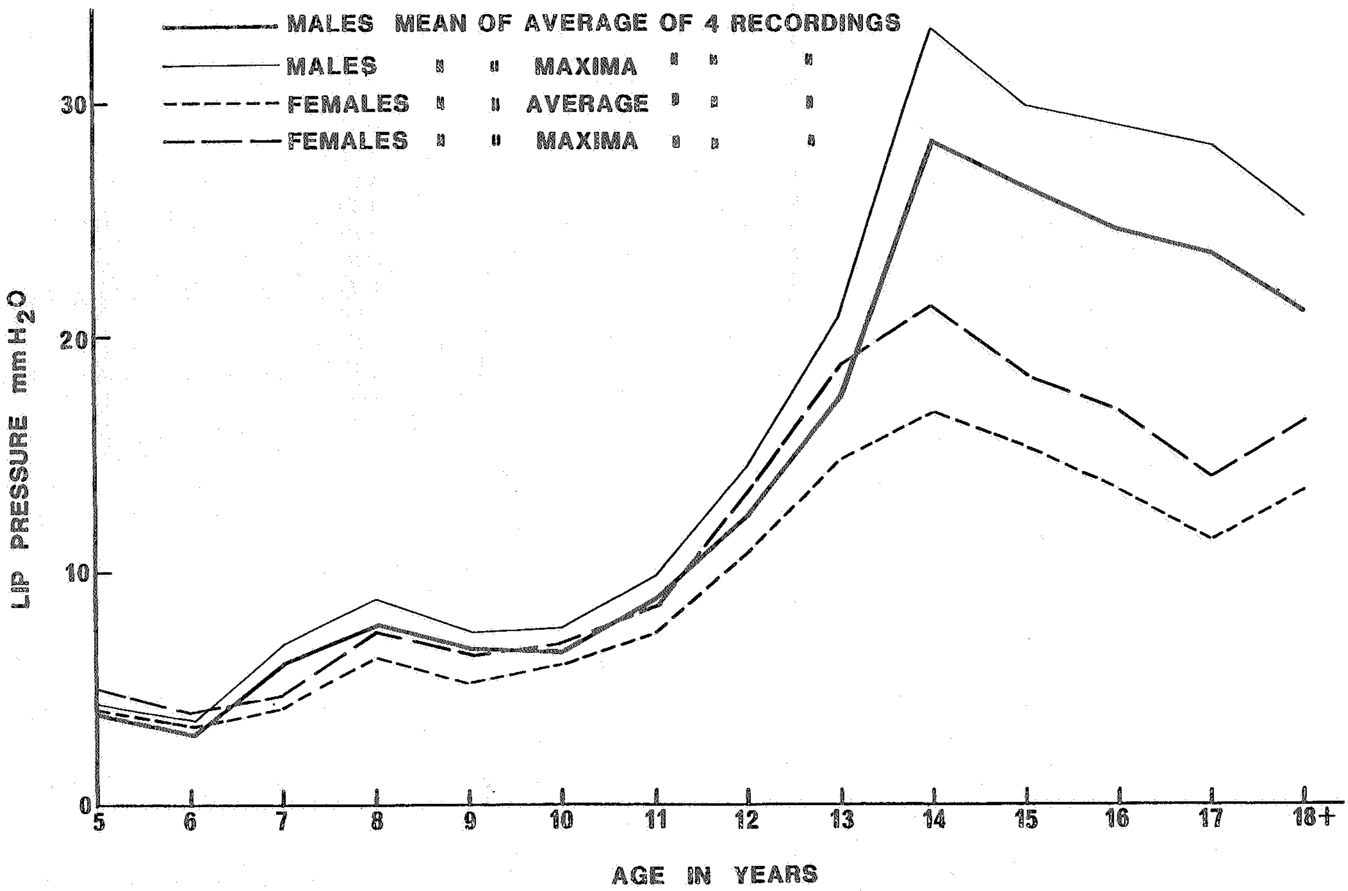

Figure 2 — Means of the average, and maxima, of 4 lip pressure recordings, for children of different ages and sexes.

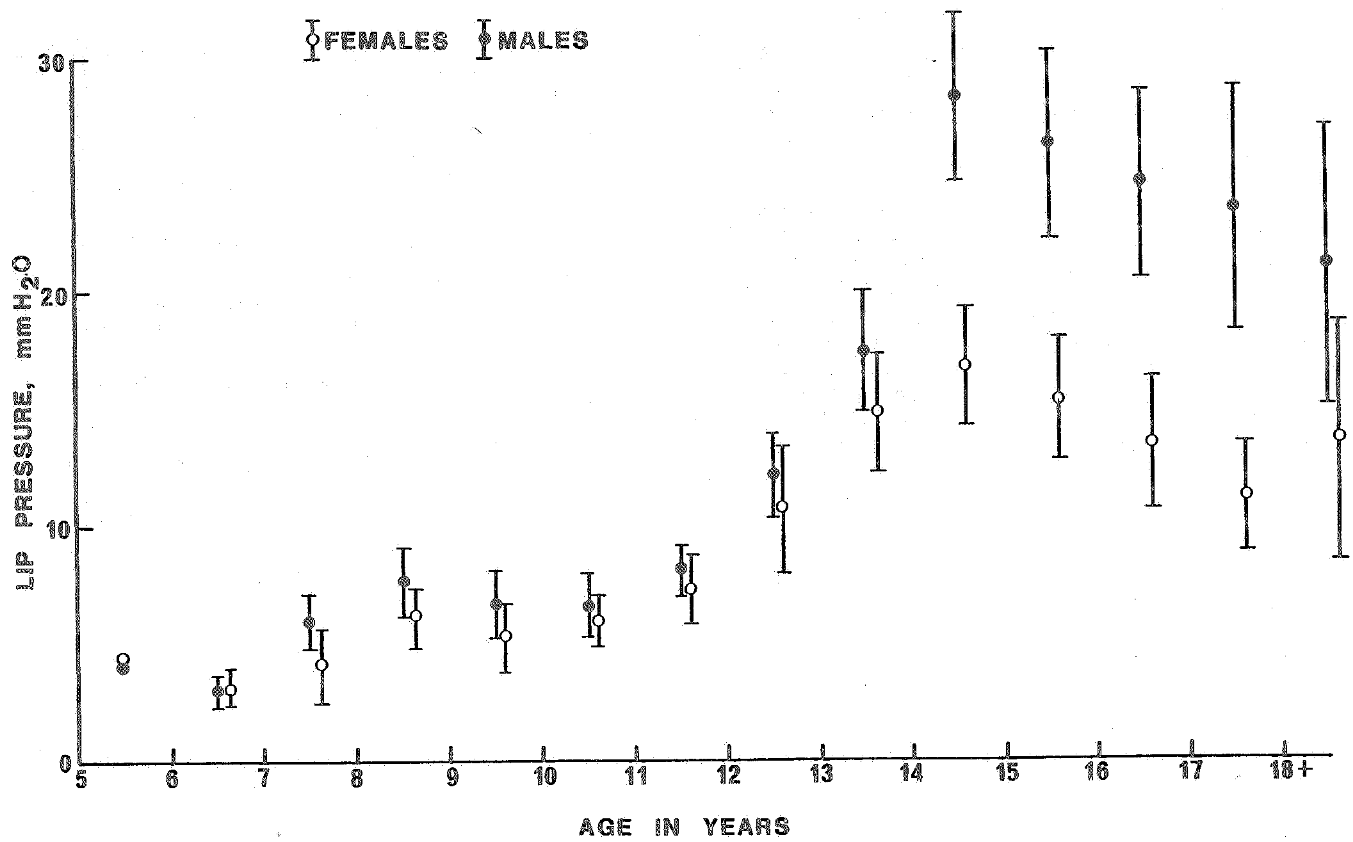

Figure 3 — 95% confidence intervals for the mean of the average of 4 lip pressure recordings for children of each sex and year of age.

Variability of Lip Pressure Between Subjects

Variability of lip pressure between children was assessed by calculating the standard deviations of the averages of the four recordings for each peer age and sex group. Not surprisingly, the standard deviations increased as the mean values increased and variability is expressed in Table 3 in terms of coefficients of variations (i.e. [standard deviation/mean] *100). The coefficient of variation varied between 44% and 83% for different peer groups, indicating quite wide ranges of lip pressures within peer groups. Males and females had very similar coefficients of variation for children of a given age. Children between the ages of 8 and 11 had slightly smaller coefficients of variation than older or younger age groups.

TABLE 3 Percentage coefficients of variation of the average of four lip pressure recordings by year of age and sex

Age	No malocclusion	
(year)	Males	Females
5	78	83
6	59	66
7	56	74
8	48	51
9	50	60
10	46	44
11	46	49
12	50	77
13	62	65
14	50	60
15	62	62
16	55	65
17	56	57
18+	53	65

Frequency Distributions and Normal Ranges

The distribution of average lip pressure within peer groups was highly skewed (large numbers of children with low recordings and a small number of relatively high recordings) for all peer groups. The shape of the frequency distributions and the influence of the proportions of zero recordings cannot be expressed adequately in terms of only the means and coefficients of variation (Tables 2 and 3). Complete frequency distributions have therefore been plotted for both sexes (Figure 4).

On the frequency distributions, the interquartile range and the range of lip pressure covering the 10-90 percentile points have been indicated. This latter range may be used as approximate confidence intervals or normal ranges for individual subjects without malocclusion within the various peer groups.

The influence of Height and Weight on Lip Pressure

Height and weight are stongly correlated with age, so these variables should also be correlated with lip pressure at least to some extent. Therefore, regression analyses were done to see whether subject height and/or weight had additional influences on lip pressure over and above those of subject age. Surprisingly, in view of the large number of subjects studied, no effects of heights could be detected and only marginally significant weight effects were noted. Even these were trivial by comparison with the magnitude of the age effects. In view of these findings, it seems that no worthwhile improvement in the accuracy of a subject's predicted lip pressure recording can be made by using information on a subject's stature in addition to his/her age.

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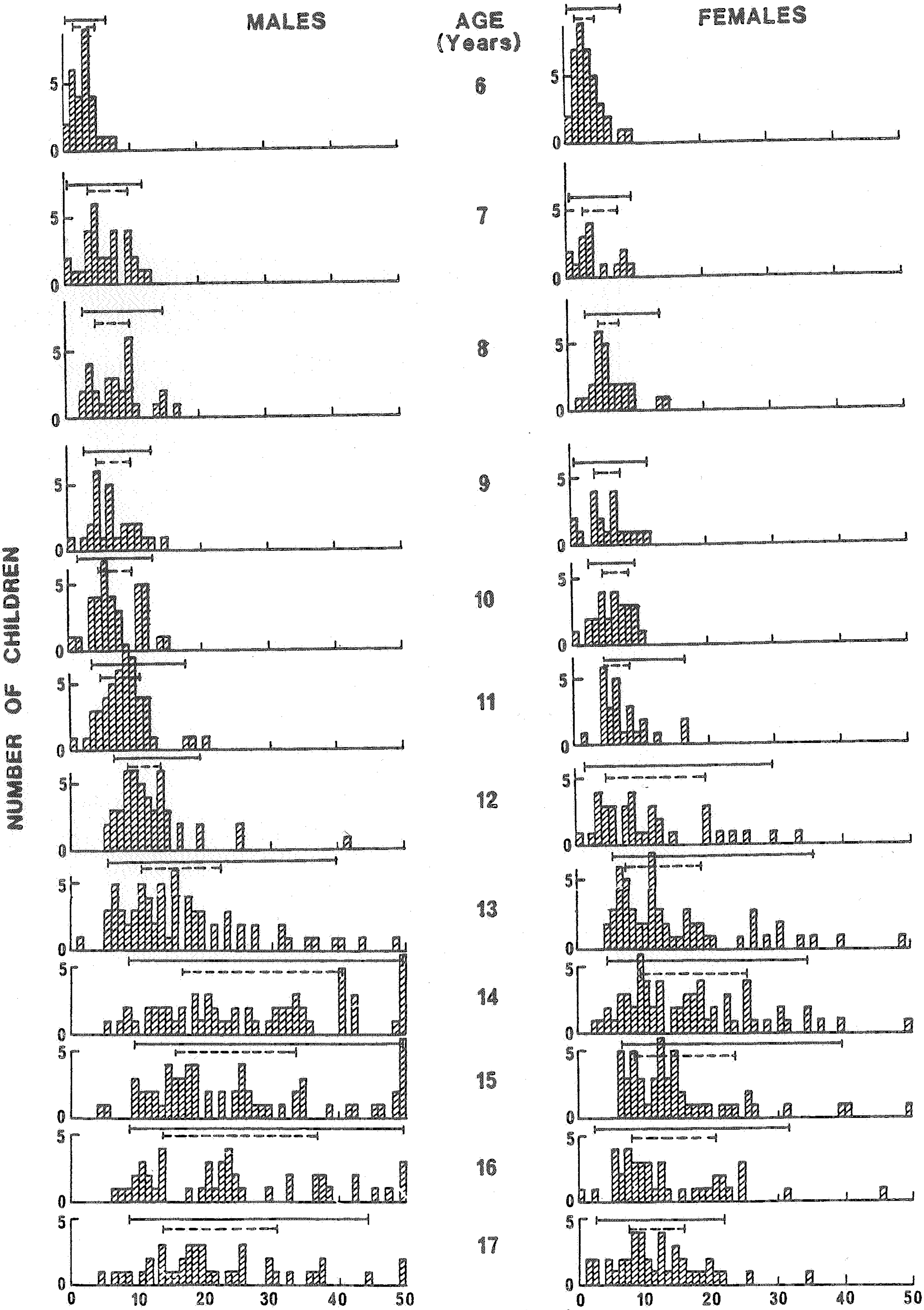

Figure 4 — Distributions of averages of 4 lip pressure recordings for children of each sex and year of age.