Effect of Lip Training in Children with Short Upper Lip

BENGT INGERVALL AND GUN-BRITT ELIASSON

Dr. Ingervall is Professor and Chairman of the Orthodontic Department, University of Bern, Switzerland. He holds a D.D.S. degree from Malmö, Sweden and Odont. dr. from the Karolinska Institutet, Stockholm, where he was also named docent in Orthodontics.

Dr. Eliasson is chief dentist in a children's dental clinic of the Public Dental Health Service of Gothenburg, Sweden. She is a dental graduate (D.D.S.) of the Royal Dental School in Malmö.

Address:
Prof. Dr. Bengt Ingervall
Klinik Für Kieferorthopädie
Universität Bern
CH-3010 Bern, Freiburgstrasse 7
SWITZERLAND

A one-year study of the effects of a simple lip exercise on incompetent lips. Upper and lower lip length were increased, and the interlabial gap reduced.

Incompetent lips may be defined as the inability to close the lips without strain. There is no normal lip seal. Incompetent lips may lead to protrusion of the teeth by reducing the restraining pressure acting on the teeth from the outside. Posen (1972, 1976) found lower than normal lip strength in individuals with bimaxillary protrusion.

Although some researchers have questioned the importance of muscle forces due to functions such as swallowing and speech, the potential importance of forces from the resting lips and cheeks and from the tongue cannot be denied (Proffit 1978).

Quite apart from the possible influence of lip incompetence on the dentition, a short upper lip may also be disfiguring. It would therefore be desirable to increase the strength and size of incompetent lips. To achieve these goals various lip training exercises have been proposed in the past (Rogers 1918, 1936) and more recently (Cooke 1977 and Fränkel 1980).

Controlled studies of the effect of lip training are still sparse. One has been presented by Barber and Bonus (1975), who found that it was possible

to increase the strength of the lips of children with primarily incompetent lips and tongue thrust by exercise. They found no change in dental relationships in spite of the increased lip strength, but it must be noted that the tongue thrust was still present. To judge the value of lip training exercises, several questions must be considered. These include the effect of lip training on the position of the teeth, the morphology of the lips, and the natural function of the lips.

This study was undertaken to elucidate these questions. The possible influence of lip training on the morphology of the dentition and the lips was evaluated with direct and cephalometric measurements. The effect on function was studied by electromyography of the lips in resting posture and during chewing and swallowing.

Subjects and Methods

Twenty-five children were included in the study, 15 in the lip training group and 10 in a control group. The age distribution in the two groups is shown in Table 1.

Most of the children were in dental stage DS2 according to the classification proposed by Björk, Krebs and Solow (1964), with permanent incisors fully erupted. The criteria for selection of the children were: 1) the clinical impression of incompetent lips due to a short upper lip, and 2) dental stage DS1, 2 or 3.

TABLE 1

Age and dental stage of the children in the lip training and control groups.

Group	Age (months) Median	Range	Number in Dental stage 1	2	3	Total
Lip training	113	92-134	5	7	3	15
Control ...	116	99-124	2	7	1	10

Bite and facial morphology

Overjet, overbite, and length and width of the dental arches were measured on casts occluded in the intercuspal position (Lundström, 1948). The median value for overjet in the lip training group was 5 mm (range 3-6mm) and in the control group 4.5mm (range 3-7mm). The corresponding values for overbite were 2.5 mm (range −0.5-4mm) and 2.5 mm (range 0.5-4.5mm). The width was measured between the first permanent molars and the length from the line connecting the molars to the central incisor (Ingervall 1970) (Fig. 1).

Cephalometric evaluation of skeletal and soft tissue facial morphology was done on profile radiographs taken with the mandible in the intercuspal position with lips relaxed. Soft tissue profile was also evaluated on radiographs taken with the mandible in the postural position with lips relaxed. The reference points and lines used are shown in Figs. 2 and 3, and the variables in Table 2. A more detailed description of the soft tissue cephalometric variables will be found in Ingervall and Janson (1981).

Electromyographic recording of lip muscle activity

Electromyographic recordings were made as described earlier by Ingervall (1978), with direct and mean voltage channels connected to an ink jet-writer. The activity in the anterior portion of the right temporal muscle was led off with bipolar hook electrodes. Bipolar surface electrodes were used on the upper and lower lips.

The muscle activity was recorded in the following sequence:

1) in the postural position of the mandible; calibration 50 μV/div, paper speed 5 cm/sec.

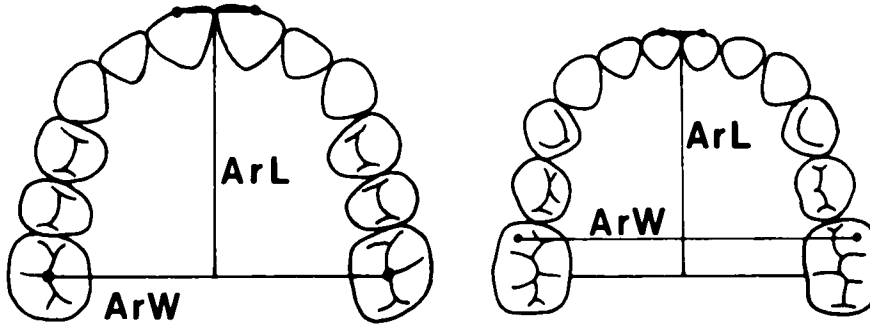


Fig. 1 Method of measuring arch lengths and widths.

TABLE 2

Dentoalveolar and skeletal variables included in the cephalometric analysis.

Linear	*Angles*
n-s	s-n-ss
n-ar	s-n-sm
n-ba	ss-n-pg
s-ba	s-ar-tgo
s-ar	NSL/NL
sp-pm	NSL/ML
pm-NSL	NL/ML
pm-NSP	IL_s/NL
ar-ss	IL_s/IL_i
n-gn	IL_i/ML
n-sp'	ML/CL
sp'-gn	ML/RL
ar-pgn	beta
is-io	
ii-io	
is-NL	

2) during swallowing of a) water and b) saliva; calibration 200 μV/div, paper speed 10 cm/sec.

3) during chewing and swallowing of a) apple and b) peanuts; calibration 200 μV/div, paper speed 10 cm/sec.

4) new recording of postural activity.

In the first test the subject was asked to relax the masticatory muscles and lips. In the second test a 5ml spoonful of water was placed in the mouth with instruction to swallow it. For the recordings during swallowing of saliva, the subject was instructed to collect saliva in the mouth and then swallow it on command. In the third test the subject was given a standard piece of fresh apple or 5 peanuts and requested to chew and swallow without waiting for further instructions.

Analysis of the electromyograms included determination of the following indices of activity of the upper and lower lips: 1) the characteristic mean voltage amplitude in the postural position, 2) the maximum mean voltage amplitude during swallowing, and 3) the maximum mean voltage amplitude during the opening and closing phases of the chewing cycle (mean of six cycles). The phase of the chewing cycle was judged from the recording of the activity in the temporal muscle (Fig. 4).

Lip training exercises

After the electromyographic and morphological recordings had been done, a program for training of the lips was instituted for the children in the lip training group. Each child was instructed to stretch the upper lip downward and press it against the upper incisors. The lower lip was stretched upward and folded over the

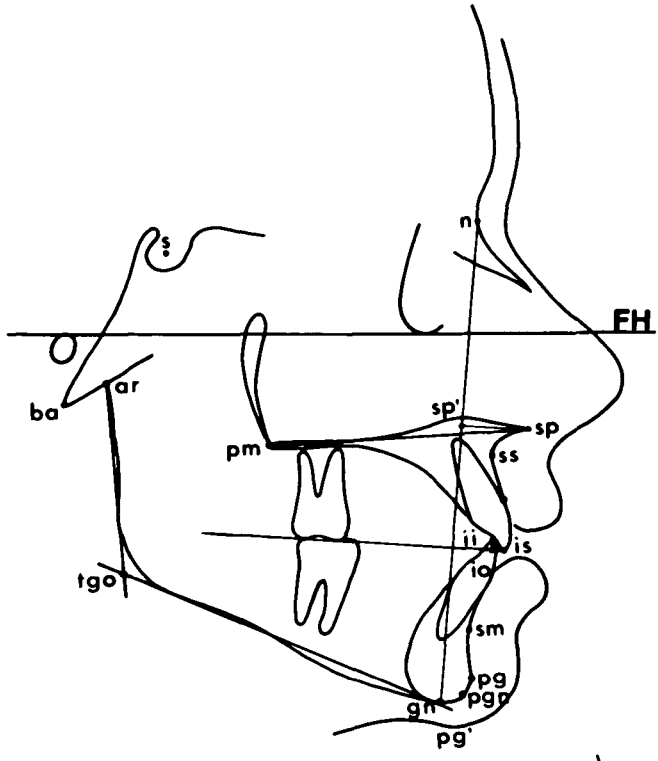
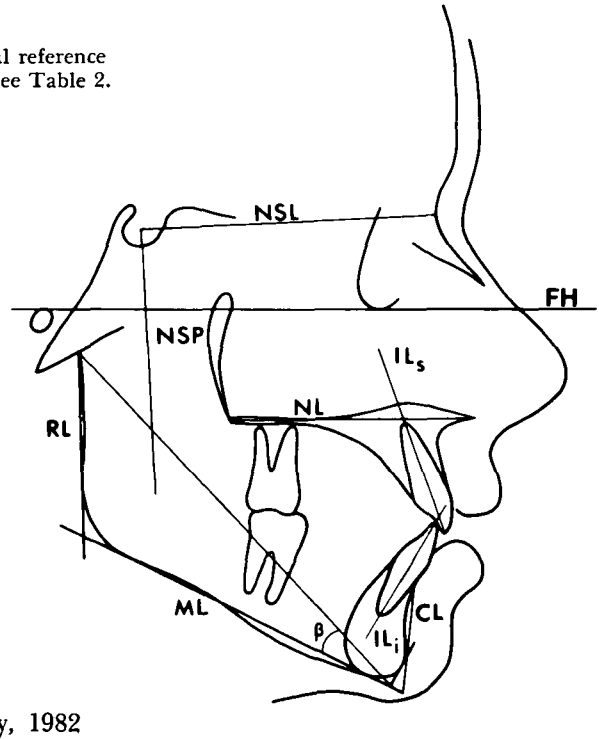


Fig. 2 Dental and skeletal reference points and lines. See Table 2.



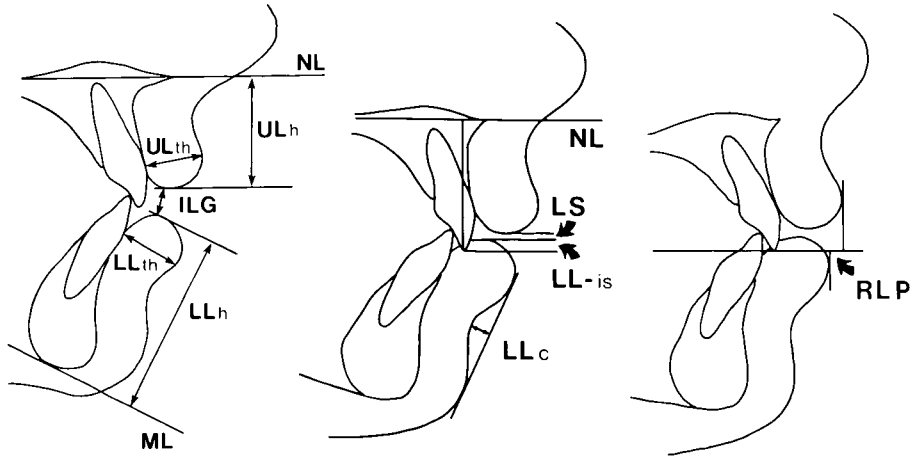


Fig. 3 Soft tissue measurements.

upper lip height (UL h)
lower lip height (LL h)
thickness of upper red lip (Ul th)
thickness of lower red lip (LL th)
depth of lower lip curvature (LL c)
relative protrusion of the lips (RLP)
interlabial gap (ILG)
lip separation (LS)
lower lip-upper incisor (LL-is)

upper lip from the outside (Fig. 5). The exercises were to be performed at least three times a day (morning, midday and evening) for a total time of at least 10 minutes each day.

The children were given regular appointments at the clinic for remotivation and follow-up. The number of visits to the clinic varied from 7 to 17, with estimated total times between 80 and 135 minutes.

After an interval of 11-14 months (median time in both groups 12 months), the recordings of lip activity and morphology were repeated. Subjects in the lip training group were instructed to continue their lip training exercises during the entire period between the "before" and "after" recordings.

Statistical methods

Differences between paired variables were tested with the Wilcoxon matched-pairs signed ranks test and between distributions with Mann-Whitney's U-test.

Results

Electromyographic activity of the lips

The electromyographically recorded activity of the lips in the postural position is shown in Table 3. There was no significant difference between the groups in the postural activity of the lips, either before (recording 1) or after the period of lip training (recording 2). Nor was there any significant difference between recordings 1 and 2 within the groups.

The swallowing activity of the lips is shown in Table 4. In the lip training group there were no significant differences in swallowing activity between recordings 1 and 2 (before and after the lip training). In the control group, on the other hand, the activity of the upper lip increased significantly ($.01 < p < .05$) from recording 1 to re-

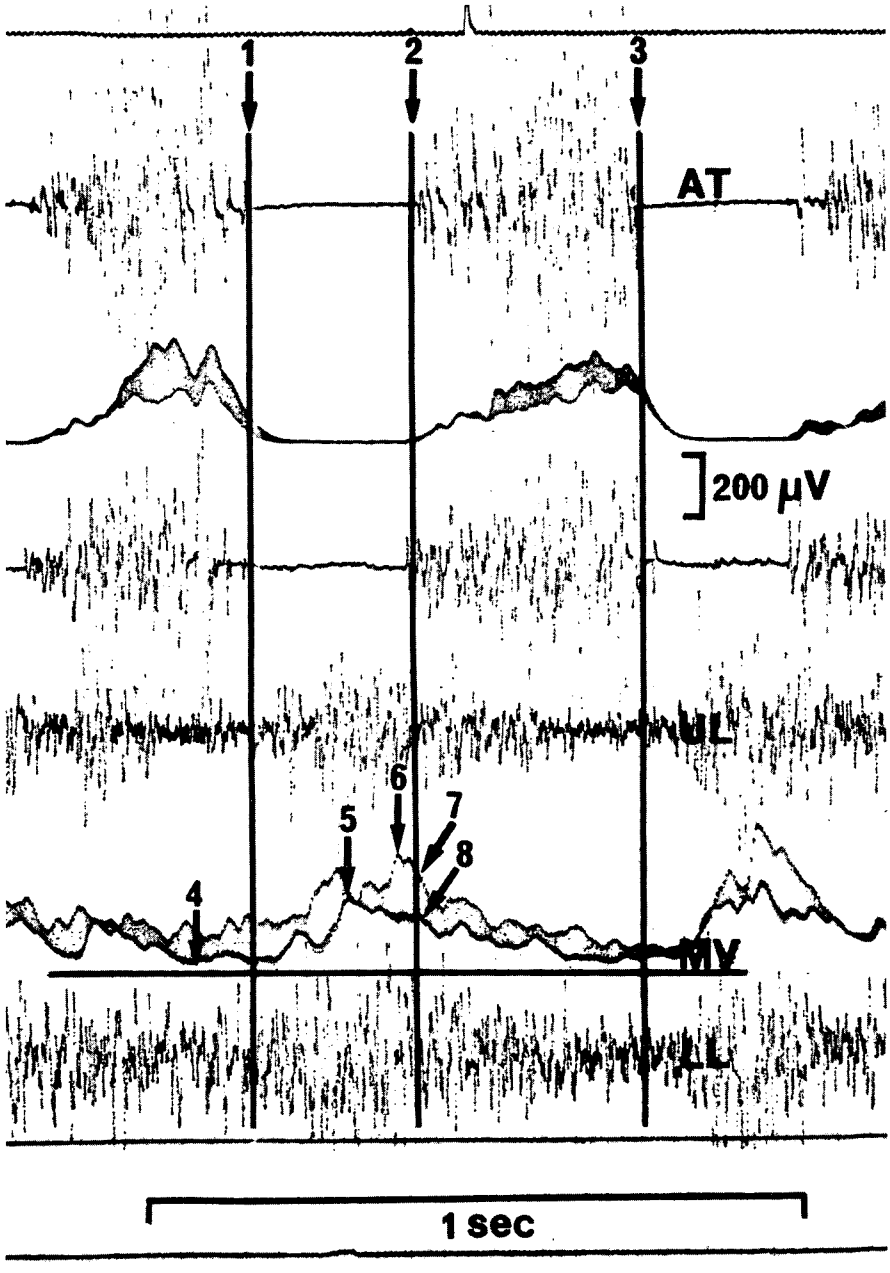


Fig. 4 Measurement of the maximum mean voltage amplitude of the lips during chewing. Distance between 1 and 2 = opening phase and between 2 and 3 = closing phase of chewing cycle. 4 = baseline of mean voltage (MV) amplitude. 5 and 8 = maximum mean voltage amplitude of upper lip (UL). 6 and 7 = maximum mean voltage amplitude of lower lip (LL).

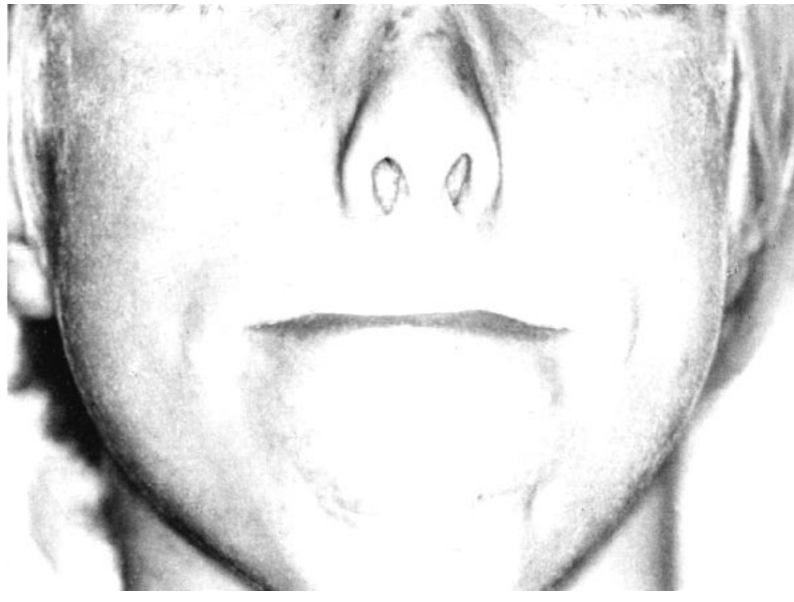


Fig. 5 The lip exercise.

cording 2 for swallowing of saliva and apple. At recording 1 there was no significant difference in lip activity between the two groups, while at recording 2 the activity of both lips during swallowing of saliva was greater in the control than in the lip training group (.01, $p < .05$).

No significant difference in chewing activity was found between recordings 1 and 2 in the lip training group (Table 5). In the control group, however, the activity of the upper lip during apple chewing increased significantly both during the closing phase and during the opening phase (.001 < $p < .01$) of the chewing cycle. There was also a significant increase of upper lip activity in the control group in the opening phase during chewing of peanuts (.001 < $p < .01$).

Bite and facial morphology

The morphological variables differing significantly between the lip training and the control groups at recording 1 (before lip training) are shown in Table 6. Facial height, lip separation and the thickness of the upper lip were greater in the lip training group.

TABLE 3

Median and range (in μV) of the characteristic mean voltage amplitude of the lips in the postural position.

	Lip training group				*Control group*			
	Recording 1		*Recording 2*		*Recording 1*		*Recording 2*	
	Median	*Range*	*Median*	*Range*	*Median*	*Range*	*Median*	*Range*
Upper lip ...	1.7	0.0-4.5	1.7	0.0-6.5	0.6	0.0-3.6	1.2	0.0-8.1
Lower lip ...	3.4	0.0-6.8	3.4	0.0-6.3	4.6	1.2-15.3	2.5	0.0-13.1

TABLE 4

Median and range (in μV) of the maximum mean voltage amplitude of the lips during swallowing.

	Lip training group				*Control group*			
	Recording 1		*Recording 2*		*Recording 1*		*Recording 2*	
	Median	*Range*	*Median*	*Range*	*Median*	*Range*	*Median*	*Range*
Water								
Upper lip ...	65	28-147	57	6-142	43	15-143	60	18-156
Lower lip ...	100	21-253	109	9-212	90	38-247	94	59-295
Saliva								
Upper lip ...	38	0-110	34	0-168	25	0-92	64	0-195
Lower lip ...	84	6-236	48	1-159	79	9-186	114	0-222
Apple								
Upper lip ...	118	45-206	129	59-236	83	26-172	123	25-210
Lower lip ...	226	32-336	175	82-369	212	102-361	215	31-290
Peanuts								
Upper lip ...	109	29-197	100	16-214	90	23-217	96	57-267
Lower lip ...	215	26-350	175	11-395	205	109-325	179	140-390

TABLE 5

Median and range (in μV) of the maximum mean voltage amplitude of the lips during chewing.

	Lip training group				*Control group*			
	Recording 1		*Recording 2*		*Recording 1*		*Recording 2*	
	Median	*Range*	*Median*	*Range*	*Median*	*Range*	*Median*	*Range*
Apple								
Closing phase								
Upper lip ...	105	46-184	106	68-170	79	11-139	135	39-236
Lower lip ...	154	77-242	151	90-221	171	46-257	150	80-310
Opening phase								
Upper lip ...	104	52-216	132	93-203	110	15-155	160	72-244
Lower lip ...	186	112-279	206	119-273	208	79-331	223	148-311
Peanuts								
Closing phase								
Upper lip ...	78	32-150	65	11-163	56	8-136	85	15-179
Lower lip ...	104	78-181	100	48-244	118	50-190	106	37-265
Opening phase								
Upper lip ...	100	22-160	99	7-173	80	8-189	109	31-231
Lower lip ...	171	118-244	168	65-267	170	86-266	157	65-301

TABLE 6

Morphological variables differing significantly between the groups at recording 1.

Variable	*Median in lip training group (mm)*	*Median in control group (mm)*	*Significance*
n-gn	109.5	105	$0.01 < p < 0.05$
sp'-gn	64	60	$0.01 < p < 0.05$
is-NL	28	26	$0.01 < p < 0.05$
In intercuspal position:			
thickness of upper red lip ...	13	12	$0.01 < p < 0.05$
interlabial gap	6	1	$0.01 < p < 0.05$
lip separation	4.5	1	$0.01 < p < 0.05$
In postural position:			
relative protrusion of the lips	0	1.5	$0.01 < p < 0.05$

The morphological analyses are shown in Table 7. In the period between recordings 1 and 2 the eruption of the upper incisors led to a significant increase in the distance between the edge of the upper incisor and the nasal line. In the lip training group there was also a significant increase in overbite and lower dental arch length. In the lip training group the height of both lips increased significantly and the interlabial gap decreased. The thickness of the upper lip decreased, and in most cases the lower lip covered the incisal edge of the upper incisor. In the control group, on the other hand, no increase in lip height was found. Instead, the interlabial gap and the thickness of the upper lip increased significantly.

At recording 2 the upper and lower lip heights were significantly greater in the lip training group than in the control group (Table 8). In contrast to recording 1, there was no longer

TABLE 7

Morphological variables differing significantly between recordings 1 and 2.

Lip training group	*Median difference (mm)*	*Significance*	*Control group*	*Median difference (mm)*	*Significance*
Overbite	—0.5	$0.01 < p < 0.05$			
Lower arch length .	0.2	$0.01 < p < 0.05$			
ii-io	—0.5	$p < 0.001$			
is-NL	—1.0	$p < 0.001$	is-NL	—1.0	$0.001 < p < 0.01$
In intercuspal position:			*In intercuspal position:* thickness of upper		
upper lip height ..	—1.5	$p < 0.001$	red lip	—0.5	$0.01 < p < 0.05$
lower lip height ..	—1.5	$0.01 < p < 0.05$	interlabial gap	—1.0	$0.01 < p < 0.05$
lip separation	2.0	$0.01 < p < 0.05$	lip separation	—1.0	$0.01 < p < 0.05$
In postural position:					
upper lip height ..	—1.0	$p < 0.001$			
lower lip height ..	—1.5	$0.001 < p < 0.01$			
thicknes of upper red lip	0.5	$0.01 < p < 0.05$			
interlabial gap	1.5	$0.01 < p < 0.05$			
lip separation	1.5	$0.01 < p < 0.05$			
lower lip-upper incisor	—1.0	$0.01 < p < 0.05$			

TABLE 8

Morphological variables differing significantly between training and control groups at recording 2.

Variable	*Median in lip training group (mm)*	*Median in control group (mm)*	*Significance*
is-NL	29	26.5	$0.01 < p < 0.05$
In intercuspal Position:			
upper lip height	24.5	21	$0.001 < p < 0.01$
In postural position:			
upper lip height	24	21	$0.001 < p < 0.01$
lower lip height	45	42	$0.01 < p < 0.05$
relative protrusion of the lips	1	2	$0.01 < p < 0.05$

any difference in lip thickness or in lip separation.

Discussion

Gustafsson and Ahlgren (1975) found that children with incompetent lips swallowed and chewed with significantly more activity of the upper lip than children with competent lips. In this investigation there was no difference in muscle activity at the start of the observation period between the lip training and the control groups.

During the observation period, however, the two groups developed differently. Lip activity did not change significantly in the lip training group, but in the control group the activity of the upper lip during swallowing of saliva and apple increased. An increase was also seen in the activity of the upper lip during chewing. At the end of the observation period the activity of the lips during swallowing of saliva was significantly greater in the control group than in the lip training group.

The different development of the level of activity in the two groups may be interpreted as a beneficial effect of the lip training. In the control group the lips, with time, increased their activity in order to compensate for their morphological inadequacy. The effect of the lip training was to increase the lip height and possibly also the functional capacity of the lips, therefore requiring no increase in activity. The relationship between capacity and activity is an inverse one.

Errors in measurement of soft tissue are greater than for hard tissue. A special source of error is variation in facial expression (Hillesund, Fjeld and Zachrisson 1978). To minimize this error, all radiographs were taken by one of the authors, closely observing the child's facial expression during the exposure.

Children with incompetent lips were found by Gustafsson and Ahlgren (1975) to have a greater anterior facial height, especially in the lower face, than children with competent lips. In this study there was greater facial height in the lip training group than in the control group, and at the start of the observation period there was a greater interlabial gap in the lip training group. No initial difference in lip height was discerned. Lip incompetence was actually worse in the lip training group than in the control group at the start of the experiment.

It is clearly possible to influence the morphology of the lips by training. In the lip training group the height of both lips increased and the lip separation decreased. No such favorable development was seen in the control group; instead, the lip incompetence became more severe. Improvement of

lip competence is accompanied by a reduction in the thickness of the upper lip, as evidenced by the different development in the two groups.

The improvement in lip height in the lip training group resulted in a significant difference between the two groups at the end of the observation period. Growth in lip height was reported by Vig and Cohen (1979). The large increase in lip height in the lip training group, however, must be attributed to the training, as changes due solely to normal growth should have been the same in both groups.

The improved function and morphology of the lips following lip training did not affect tooth position to any measurable extent. Overjet and incisor inclination were unchanged. There was a small increase in overbite in the lip training group, but this could have been a result of normal tooth eruption.

Barber and Bonus (1975) also failed to find any influence of lip training on the teeth, although lip strength increased considerably. They implied, without offering any evidence, that there had been changes in lip morphology.

This study did find evidence of changes in lip morphology, substantiating the clinical impression of Harrington and Breinholt (1963) that lip training can positively affect lip morphology.

The lip changes that were found were small and not obvious without measurement. These changes required a considerable amount of motivation and effort on the part of the dentist as well as the children and their parents.

It is possible that other types of lip training exercises could have been more effective. This is one aspect of an ongoing investigation in which lip training with the aid of oral shields is being studied.

The fact that no appliance or artificial aid is necessary for the lip training method used in this study may actually be an advantage. It can be difficult to motivate children to perform a complicated training program for a long period of time. An important advantage of the lip training method used is that the exercises can be done at all times of the day, including the time spent in school and outdoors. Our experience in the present study indicates that once the exercises had become routine, the children did them during brief periods distributed over the entire day.

It is a very important finding of this study that even simple types of training exercises can have a positive effect on lip morphology and lip function.

Summary

The effect of lip training was studied in 15 children with incompetent lips, who were compared with a control group of 10 children who also had incompetent lips. Lip function was evaluated by electromyography of the activity of the lips in resting posture and during swallowing and chewing. The morphology of the dentition, facial skeleton and lips were studied on dental casts and profile radiographs.

Lip training was performed for one year and was found to maintain lip function in the test group, in contrast to impairment of lip function in the control group. Lip training favorably influenced lip morphology, increasing the height of both lips and decreasing the interlabial gap.

In the control group, the interlabial gap increased.

The beneficial effect of the training on the function and morphology of the lips could not be shown to affect tooth position during the one-year study period.

REFERENCES

Barber, T. K., and Bonus, H. W. (1975): Dental relationships in tongue-thrusting children as affected by circumoral myofunctional exercise. *J. Am. Dent. Ass.*, 90: 979-988.

Björk, A., Krebs, Aa., and Solow, B. A. (1964): A method for epidemiological registration of malocclusion. *Acta Odontol. Scand.*, 22:27-41.

Cooke, M. S. (1977): A lower fixed lingual tongue crib and lip toning exercises: Report of an unusual case. *Br. J. Orthod.*, 4:143-148.

Fränkel, R. (1980): Lip seal training in the treatment of skeletal open bite. *Europ. J. Orthod.*, 2:219-228.

Gustafsson, M., and Ahlgren, J. (1975): Mentalis and orbicularis oris activity in children with incompetent lips. *Acta Odontol. Scand.* 33:355-363.

Harrington, R., and Breinholt, V. (1963): The relation of oral-mechanism malformation to dental and speech development. *Am. J. Orthod.*, 49:84-93.

Hillesund, E., Fjeld, D., and Zachrisson, B. (1978): Reliability of soft-tissue profile in cephalometrics. *Am. J. Orthod.*, 74:537-550.

Ingervall, B. (1970): Positional changes of mandible and hyoid bone relative to facial and dental arch morphology. *Acta Odontol. Scand.*, 28:867-894.

Ingervall, B. (1978): Activity of temporal and lip muscles during swallowing and chewing. *J. Oral Rehabil.*, 5:329-337.

Ingervall, B., and Janson, T. (1981): The value of clinical lip strength measurements. Am. J. Orthod., 80:496-507.

Lundström, A. (1948): Tooth size and occlusion in twins. S. Karger, Basel.

Posen, A. L. (1972): The influence of maximum perioral and tongue force on the incisor teeth. *Angle Orthod.*, 42:285-309.

Posen, A. L. (1976): The application of quantitative perioral assessment to orthodontic case analysis and treatment planning. *Angle Orthod.*, 46:118-143.

Proffit, W. R. (1978): Equilibrium theory revisited: Factors influencing position of the teeth. *Angle Orthod.*, 48:175-186.

Rogers, A. P. (1918): Muscle training and its relation to orthodontia. *Int. J. Orthod.*, 4: 555-577.

Rogers, A. P. (1936): Place of myofunctional treatment in the correction of malocclusion. *J. Am. Dent. Ass.*, 23:66-78.

Vig, P. S., and Cohen, A. M. (1979): Vertical growth of the lips: A serial cephalometric study. *Am. J. Orthod.*, 75:405-415.