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Effect of Orofacial Myofunctional Exercise Using an Oral Rehabilitation Tool on Labial Closure Strength, Tongue Elevation Strength and Skin Elasticity

Fatimah Ibrahim[1)], Nooranida Arifin[1)], Zubaidah H A Rahim[2)]

[1)] *Medical Informatics and Biological Micro-electro-mechanical systems (MIMEMS) Specialized Laboratory, Department of Biomedical Engineering, Faculty of Engineering, University of Malaya: Kuala Lumpur, 50603, Malaysia. E-mail: fatimah@um.edu.my*
[2)] *Department of Oral Biology, Faculty of Dentistry, University of Malaya*

Abstract. [Purpose] This paper reports the effects of orofacial myofunctional exercise using an oral cavity rehabilitation device on physiological parameters that include labial closure strength, tongue elevation strength, and the right and left facial skin elasticity. [Subjects] Seventeen females aged forty years old and above were initially recruited for this study. Thirteen performed the exercise for 14 weeks, and only 11 subjects continued the exercise for another 10 weeks. [Methods] Subjects were instructed to perform an orofacial myofunctional exercise using an oral rehabilitative device for three minutes, for four times a day. The non-parametric Wilcoxon test was conducted to examine the significance of physiological parameters induced by the orofacial myofunctional exercise. The measurements of the physiological parameters were carried out weekly for 14 weeks and 24 weeks after the intervention for 13 and 11 subjects, respectively. [Results] The findings showed that there were significant improvements in the median values of all parameters before and after performing the orofacial myofunctional exercise for 14 weeks or more. [Conclusion] These results suggest that the orofacial myofunctional exercise can be regarded as a potential non-invasive therapy for improvements of the labial closure strength and tongue elevation strength, which indirectly provide support for the facial tissue, and enhances facial skin elasticity.
Key words: Orofacial myofunctional exercise, Tongue elevation strength, Labial closure strength

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INTRODUCTION

The facial musculature consists of the muscles of the upper face, mid-face and lower face and neck. The facial musculature has important roles in performing a variety of orofacial functions such as speech, mastication, and swallowing[1, 2)]. The facial muscles, in particular the mimetic muscles, also perform many complex functions such as the expression of emotion and affection[2)]. The mimetic muscles largely gather around the orbicularis oris which forms the shape of the lips. Therefore, contraction of the orbicularis oris may be achieved by exercising the lips[3, 4)]. A study by Stanc and Fogel[5)] showed that the ability to control lip or oral continence is achievable through the synergism of several factors, and one such factor is the strength of orbicularis oris muscle. Much of the tissues of the lips are made up of the orbicularis oris muscle which act as a sphincter muscle around the mouth[6)]. One of the functions of orbicularis oris muscles, among others, is to shape and control the size of the mouth opening, which is important for creating the desirable lip positions and movements during speech[6)]. A weak orbicularis oris is characterised by a poor occlusal relationship[7)], decreased force of bite[8)], poor chewing ability, drooling and articulation difficulties. Exercises associated with the function of the muscles of the face and lips can be called orofacial myofunctional exercises.

Speech and swallowing processes are also closely associated with the tongue. The opening and closing of the lips are highly correlated with the swallowing process; and are important for the oral phase of swallowing and saliva management[9, 10)]. Therefore, abnormal tongue function results in "impaired mastication, poor bolus formation, abnormal bolus positioning, oral residue, disorganized oral transit and premature spillage of bolus into the pharynx" and which might lead to more complicated clinical symptoms such as dysphagia or impaired swallowing[11)]. A weak tongue could also lead to dysarthia or poorly articulated speech, resulting from interference in the control of the muscles involved in speech. This implies that having strong lips and tongue are crucial for enhancing the quality of oral functions in health.

Noro et al.[12)] conducted a study to evaluate the changes of labial closure strength (LCS) in relation to age and gender in healthy and unhealthy subjects. In their study, the unhealthy subjects were those who had diseases or symptoms as follows: oral respiration, tonsillitis, adenoiditis, atopy,

asthma, sinusitis, snoring, and life-style related diseases. Their results revealed that the unhealthy subjects had significantly low LCS values compared to the healthy subjects. This indicates that LCS is a potential indicator and parameter of healthy oral functions.

The objective of our study was to investigate the effect of an orofacial myofunctional exercise using a lip rehabilitation device on the LCS, tongue elevation strength (TES) and facial skin elasticity (SE) of the right (ER) and left (EL) quadrants of the face. We wanted to determine if the exercise would influence and improve orofacial functions.

SUBJECTS AND METHODS

Seventeen female participants aged 40 years and above were recruited for this study. All participants were recruited via posters displayed at the University of Malaya and advertisements in the University of Malaya E-Mailing System. The advertisements were designed to recruit healthy individuals and those who were suffering from snoring, bad breath, mouth breathing, asthma, allergy, bleeding gum, sleep apnea, blocked nose, mouth ulcer, frequent urination, high blood pressure or diabetes. Self-administered questionnaires were distributed to all the participants to obtain their i) demographic data, ii) health status, iii) information of facial skin condition, iv) facial surgery information and v) facial skin appearance. Informed consent was obtained from each participant, they had been provided with a full explanation of the objectives and protocol of the study. The study was approved by the Medical Ethics Committee of the Dental Faculty, University of Malaya, approval number: DF OB0502/0020 (L).

An oral baseline measurement was conducted to verify the baseline strengths of the LCS and TES of each subject. LCS and TES were measured using LCS and TES indicators from Lip DeCum®/LDC-110, Dental Yuni Corporation, Japan. The subjects were grouped according to their LCS and TES strengths. This was necessary to avoid side effects, such as mouth ulcer, if the oral rehabilitation device proved too rigid for the subjects. Accordingly[12, 13], subjects with LCS strength below 5 N, or above 5 N, and greater than 14 N were given a green (LCS value$<$5 N), pink (LCS value 5−14 N) or blue (LCS value$>$14 N) oral rehabilitation device, respectively.

The study employed an oral rehabilitation device (Patakara® LIP Trainer, Dental Yuni Corporation, Japan). This device is specially designed to encourage uniform application of the force around the lip muscle during the orofacial myofunctional exercise. It is made from a highly elastic polymer plastic with rubber composite (polyester elastomer). Noro et al.[12] have validated the device with 4,103 subjects, and reported the effects of oral myofunctional exercise using it in people of all ages. In our study, the subjects were instructed to perform orofacial myofunctional exercise using the oral rehabilitation device four times a day, and for three minutes per session to ensure optimum effectiveness of the device [12]. For the first exercise, subjects grip the rehabilitation device for two minutes using only their lips. This step strengthens the orbicularis oris muscles of the lips[3]. In the remaining one minute, subjects perform an orofacial myofunctional exercise following the given training method[13]. Subjects were supplied with a self-check list to record their daily routine exercise and give comments on their health status. They were required to bring their individual checklists when they attended weekly measurements. Practice sessions were held for each subject prior to the experiment to ensure the exercise would be conducted effectively. All the LCS, TES, and SE measurements were taken before the intervention to determine baseline values, and every week after the start of experiment.

The LCS was measured using a LCS indicator (Lip DeCum®/LDC-110, Dental Yuni Corporation, Japan). The measurement is converted into a loading value in Newtons by four sets of strain gauges on the sensor. A polypropylene made lip holder was mounted on the sensor of the LCS indicator. During the measurement, the subjects were required to sit upright and grip the lip holder with their upper and lower lips using their utmost possible strength. The TES measurements of the subjects were carried out using a TES Indicator (Lip DeCum®/LDC-110, Dental Yuni Corporation, Japan). In order to protect the surface of the pressure transducer from moisture and to ensure sterilization of the instrument, a disposable plastic coat was placed over the load cell surface and stem[14]. While the subjects held to the device stem for further stabilization, the TES indicator device was set at the anterior position of the mouth palate. The load cell surface was required to be pressed by the subjects with their tongue tip with the utmost possible strength while keeping the jaw in a fixed position.

SE measurement was conducted using a Cutometer SEM 575, which was connected to an IBM compatible PC via a serial RS-232-C port for operation. This device basically operates based on the principle of suction elongation to measure the elastic properties of skin using an optical measuring unit. The time/strain mode with a 5-s application of load 450 mbar load was used, followed by two seconds of relaxation and was repeated twice. The elastic recovery ratio of pliability (Ua) and maximal skin extension (Uf) were used in the analysis. Ua/Uf represents the gross elasticity of the skin. All the measurements of LCS, TES, and SE were carried out in triplicate.

The non-parametric Wilcoxon test was conducted using SPSS version 13 to examine the significance of the changes in LCS, TES, and SE after performing the orofacial myofunctional exercise for 14 and 24 weeks.

RESULTS

Out of the seventeen subjects recruited, only three subjects had an unknown medical history. One subject claimed to have more than one health problem, sleep apnea, blocked nose, mouth ulcer and diabetes. The most common health problems encountered were allergy and bleeding gums. Only 13 subjects out of the 17 recruited attended the LCS, TES and SE measurements for the first 14 weeks, and only 11 continued attending for another 10 weeks.

Since the sample size was small and measurements were performed every week, for each subject, this study

Table 1. The median, mean, and range of LCS, TES, ER and EL of 13 subjects before and after14 weeks intervention

	Labial Closure Strength (LCS), N		Tongue Elevation Strength (TES), N		Right Facial Skin Elasticity (ER)		Left Facial Skin Elasticity (EL)	
	Week 1	Week 14	Week 1	Week 14	Week 1	Week 14	Week 1	Week 14
Median	5.2*	9.8*	2.7*	4.7*	0.45*	0.57*	0.50*	0.58*
Mean	5.7±3.0*	9.6±3.5*	3.0±1.3*	5.2±2.5*	0.43+0.16*	0.57±0.06*	0.48±0.14*	0.58±0.05*
Range	0.4 – 10.6	4.9 – 15.1	1.1 – 5.5	1.6 – 9.2	0.13 – 0.65	0.45 – 0.67	0.18 – 0.68	0.51 – 0.67

*statistically significant at p≤0.05

Table 2. The median, mean, and range of LCS and TES of 11 subjects before and after 24 weeks intervention

	Labial Closure Strength (LCS), N		Tongue Elevation Strength (TES), N	
	Week 1	Week 24	Week 1	Week 24
Median	4.9*	12.8*	2.7*	9.7*
Mean	4.9* ±2.5	12.9* ±4.8	2.7* ±1.1	10.7* ±5.6
Range	0.4 – 10.3	6.5 – 22.2	1.1 – 5.5	2.8 – 25.5

*statistically significant at p≤0.05

had a repeated-measures design. Thus, the non-parametric Wilcoxon test was appropriate for the statistical analysis. Thirteen subjects (Mean age 44.7±3.4 SD) successfully performed the orofacial myofunctional exercise regularly as requested. Table 1 shows the results of the facial elastic recovery ratios on the right (ER) and left (EL), LCS, and TES before and after performing the orofacial myofunctional exercise for 14 weeks. The findings show that there were significant improvements (p≤0.05) in the median and mean values of LCS, TES, EL and ER from before (LCS=5.2 N, TES=2.7 N, EL=0.45, ER=0.50) to after (LCS=11.3 N, TES=4.7 N, EL=0.57, ER= 0.58) performance of the orofacial myofunctional exercise.

The mean and median values of LCS and TES of 11 subjects, before and after the intervention, on Weeks 1 and 24 are summarized in Table 2. The median value of LCS increased from 4.9 N (week 1) to 12.8 N (weeks 24), while the median value of TES increased from 2.7 N (week 1) to 9.7 N (week 24). The mean of maximum LCS values before orofacial myofunctional exercise among the subjects was 4.9 N and increased to 12.9 N; and the mean of maximum TES values before orofacial myofunctional exercise was 2.7 N and increased to 10.7 N after 24 weeks. The Wilcoxon test results indicate that there were significant differences between paired measures (p≤0.05) of LCS and TES before and after performing the oral stretching exercise for 24 weeks. These results suggest a benefit of orofacial myofunctional exercise which increased LCS and TES of adult females. It is conceivable that prolonged exercise would result in higher values of LCS and TES.

DISCUSSION

The most challenging issue in this study was getting the commitment of the subjects to regularly perform the orofacial myofunctional exercise as requested. The results show significant increases in the median values of all the parameters evaluated after 14 and 24 weeks, of 13 and 11 subjects, respectively. The findings indicate a benefit of orofacial myofunctional exercise which increased LCS, TES and SE in adult females. The results show that LCS, TES and SE values increased, consistent with the duration of the exercise regime. In addition, the subjects that performed the exercise regime reported that they experienced better health. The variation in the results observed may have arisen from the inability of the subjects to strictly follow the regime. This may have led to variation in the rate of increment of LCS, TES and SE among the subjects.

Weak LCS and TES may cause mouth breathing and snoring during sleep[12]. Having strong lip seal and tongue may facilitate nasal respiration during sleep as opposed to habitually performing oral respiration to. Nasal respiration during sleep would improve the cardiovascular system response via changes in velocity in the facial artery[15]. The heart rate would increase due to stimulation of baroreceptors in the lungs which would subsequently increase the cardiac output[16]. Therefore, there would be higher blood flow in the superficial capillaries that supply tissue (such as facial skin) with oxygen and nutritive substances and remove waste metabolites as well[17]. During exercise, the contracting muscles would consume higher volumes of oxygen (O_2) than in the rest condition, while, the partial oxygen (PO_2) venous blood from exercising muscle would decrease to approximately to zero, as reported by Ibrahim et al.[3] The dilation of the capillary bed of contracting muscle and reopening of the closed capillaries would greatly reduce the mean distance from the blood to the tissue cells. This would facilitate the movement of O_2 from blood to cells[18]. Thus, higher concentrations of oxygen would be supplied to the tissues and indirectly nourish the skin.

Skin elasticity measurements showed increases at the end of the Week 14, for all subjects on the left and right

sides of the face. These results also indicate a benefit of orofacial myofunctional exercise which also increased LCS and TES. We assume that the more frequent the participant performed the orofacial myofunctional exercise, the more the LCS value would increase. However, we have to accept that not all of the participants managed to perform orofacial myofunctional exercise four times a day for the duration of 24 weeks. This may have lead to a variation in the rates of increment in LCS among the subjects. Physiological orofacial functions do not usually require the isolated contraction of individual muscles. In contrast, most of these complex functions simultaneously involve many muscles, (i.e. those functions mainly involving the orbicularis oris (OOS) and orbicularis oris inferior (OOI) muscles usually recruit the muscles fixating the corners of the mouth simultaneously[2]). This was reported by Ibrahim et al.[4]) who showed that OOS and OOI of the lower and upper lips are the major muscles that undergo muscle contraction during orofacial myofunctional exercise using the same rehabilitation device.

Our results show that orofacial myofunctional exercise performed for 14 weeks helps to improve the LCS, TES and SE. The exercise also enhanced facial skin elasticity, indirectly nourishing facial tissue. In addition, extending the period of orofacial myofunctional exercise to 24 weeks significantly improved LCS and TES.

To the best of our knowledge, there is no consensus regarding a standard exercise therapy for orofacial myofunction. Different devices and techniques have been suggested for therapeutic purposes, such as oral screen treatment[21–23]) for the lip muscles and lingual exercises[19, 20, 23, 24]) for the tongue muscle. Thus, the exercise used in our present study may have potential use as a therapeutic tool for speech, swallowing in dysarthric and dysphagic populations[10, 20, 22, 24]) and other diseases[21, 23]). However, future studies should include larger numbers of subjects and validate the study clinically.

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