Published in final edited form as:

Br J Oral Maxillofac Surg. 2013 December ; 51(8): 908–912. doi:10.1016/j.bjoms.2013.09.002.

A 3D Anthropometric Analysis of the Orolabial Region in Chinese Young Adults

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Abstract

The orolabial region frequently undergoes significant changes following trauma, orthognathic surgery or orthodontics. Ethnicity, age and gender specific normative data are needed during the planning phase before surgical interventions in this region. In 2008 the British Journal of Oral and Maxillofacial Surgery published anthropometric lip measurements of Chinese children; however such reference data for Chinese young adults are currently unavailable. Therefore this cross-sectional study using 3-D facial photographs acquired from 103 healthy Chinese young adults with Class I skeletal pattern was conducted to deliver normative data for this age group.

Anthropometric landmarks were identified on these 3-D images and linear, angular measurements as well as proportions were calculated. It was found that all orolabial measurements were significantly higher in males other than the labiomental angle. No gender differences were found in the anthropometric proportions. This study established the orolabial anthropometric normative data for Chinese young adults. These norms can be used to objectively evaluate the morphology of the lips during diagnosis, treatment planning and assessment of treatment outcomes.

Introduction

The orolabial region plays an important role in aesthetics, facial expression, speech and eating. The shape of Cupid's bow, the length and projection of the lips are considered to be indicators of youth, health and attractiveness.¹ Fuller lips have been reported as a hallmark of beauty and fertility.^{2–4} Due to its unique anatomical features, this region has also been the subject of various rejuvenation procedures including augmentation cheiloplasty, soft tissue fillers, laser assisted and chemical peeling.^{5, 6} The orolabial region is frequently affected by treatment procedures dealing with congenital deformities, trauma and orthognathic surgery as well as during orthodontic teeth movement.

Features of the lips tend to differ depending on age and ethnicity. Most orthodontic literature using cephalometry or 2-D photography has addressed the profile lip relationships due to treatment or growth.⁷ In a 2008 article published in the British Journal of Oral and Maxillofacial Surgery, Zhu et al.⁸ documented anthropometric lip measurements of Chinese children using calipers. Such studies would aid in the planning of cleft-lip surgery for

children. However, ethnicity, age and gender specific, normative data are required when analyzing and comparing aesthetic outcomes of repaired cleft lips in young adults with normative values of a non affected control group. To the best of the authors' knowledge such reference data on orolabial dimensions in Chinese young adults are yet unavailable in literature. Such normal values may be employed as 1) benchmarks for treatment outcomes, and 2) reference data in treatment planning before orthognathic or aesthetic surgical procedures. Therefor the aim of this study was to determine gender-specific normative orolabial anthropometric measurements for Chinese young adults.

Materials and Methods

Study Design

This was a cross-sectional study using 3-D facial photographs acquired from 103 healthy Chinese adults (51 men and 52 women). The inclusion criteria were;

- Ethnic Chinese
- Between 18-35 years of age
- Class I skeletal pattern
- Absence of significant facial anomalies

Subjects with a history of orthognathic or plastic surgery, lip incompetence were excluded. This study was approved by the Institutional Review Board (Protocol No: UW 12-066). The patient sample used for this study was identical to the one used in our previous publications.⁹

Imaging Procedure

Each subject was imaged using the *3dMDface* stereophotography system (3dMD, Atlanta GA, USA). This imaging system consisted of two pods, each housing three cameras (two grayscale and one color) synchronized and directed at a specific angle. The system was calibrated before each imaging session. The participants were imaged while being seated in front of the camera, looking at a mirror, maintaining a neutral position and expression.

Image analysis

All 3-D facial photographs were analyzed with the 3dMD Vultus software by a single operator. Anthropometric landmarks were identified on these images according to definitions by Farkas¹⁰ and Kolar¹¹ (Table 1 and Figure 1). Once these landmarks were identified, the software automatically calculated the linear distances and angles between them. Based on these landmarks the following anthropometric measurements were calculated:

Transverse linear measurements:

- i. Mouth width (ch-ch)
- ii. Philtrum width (cph-cph)

Vertical linear measurements:

- i. Upper lip height (sn-sto)
- ii. Cutaneous upper lip height (sn-ls)
- iii. Upper vermilion height (ls-sto)
- iv. Lower vermilion height (sto-li)
- v. Cutaneous lower lip height (li-sl)
- vi. Lower lip height (sto-sl)

Angular Measurements

- i. Labiomental angle (li-sl-pg)
- ii. Interlabial angle (sn-ls/li-sl)

The interlabial angle is a new measurement which was not making part of the traditional anthropometric analysis scheme. The following proportional indices were calculated;

- i. Lip height index ($\text{sto-sl/sn-sto} \times 100$) - ratio between the lower lip height and the upper lip height
- ii. Upper vermilion-cutaneous lip index ($\text{ls-sto/sn-sto} \times 100$) - ratio between the vermilion and cutaneous parts of the upper lip
- iii. Lower vermilion-cutaneous lip index ($\text{sto-li/sto-sl} \times 100$) - ratio between the vermilion and cutaneous parts of the lower lip
- iv. Upper lip height mouth width index ($\text{sn-sto/ch-ch} \times 100$) - ratio between the height of the upper lip and width of the mouth
- v. Lower lip height mouth width index ($\text{sto-sl/ch-ch} \times 100$) - ratio between the height of the lower lip and width of the mouth

Proportions ii to v are new parameters which were not part of the traditional anthropometric analysis scheme.

Statistical analysis

Descriptive statistics including the mean and standard deviation was determined for the male and female groups. Gender differences were explored using Student's t test with the alpha level set at 0.05. All statistical analysis was performed with the PASW 18 software (SPSS, Chicago, IL, USA).

Results

The average age for males was 24.2 ± 3.03 years and 23.58 ± 3.91 years for females. No statistically significant differences were found between these two groups ($p=0.372$).

The means and standard deviations of the linear and angular anthropometric measurements for the Chinese young adults are depicted in Table 2. Except the labiomental angle, all orolabial measurements were significantly higher in males. However, no gender differences were found in the anthropometric proportions (Table 3).

Discussion

the lip morphology is needed when planning lip reconstruction in cleft lip palate patients and performing orthognathic surgery or orthodontic anterior teeth movement, as movements of underlying hard tissues will change the lip position after the treatment.¹² Thus the norms presented in this study might serve as reference values during the initial assessment of patients. For patients requesting aesthetic lip surgery, surgeons might use these values as a benchmark for treatment planning, measurement of treatment outcome after lip surgery, orthognathic, or orthodontic treatment, respectively. Significant gender differences with males having higher values for all linear measurements were found in this study. However, these differences disappeared when proportional indices were computed. This may indicate that the gender differences in the linear measurements may have arisen due to the relative differences in body size between genders, rather than due to differences in shape of the orolabial region.

Figures 2 and 3 depict a comparison of our results with those reported by Farkas¹⁰ for North American White (NAW) and African American (AA) young adults. Such a comparison would be valid as previous researchers have demonstrated a good agreement between manual anthropometry and digital measurements taken from stereophotographs.¹³⁻¹⁵ The mouth width of Chinese appears to be smaller in both males and females than NAW's and AA's. Both upper and lower vermilion heights of Chinese males are longer than NAW's but shorter than AA's. In contrast, Chinese females vermilion heights were more akin to the NAW's.

We introduced some new measurements/proportions which were not part of the traditional analysis scheme. The interlabial angle, adapted from cephalometry, might be especially useful when evaluating patients with bimaxillary protrusion. The proportions upper and lower vermilion-cutaneous lip indices would be useful to evaluate outcomes of procedures where the degree of exposure of the vermilion changes, such as in secondary cleft lip surgery. Likewise the upper and lower lip height mouth width indices might be of help in monitoring changes in the vertical dimension related to transverse changes of the mouth width, such as in reconstruction of facial clefts or in surgery for macro- or microstomia.

Studies to document lip anthropometry conducted in the past have been based on direct measurements, 2-D photographs, cephalograms or plaster casts. The standard frontal/lateral photographs or cephalograms fails to provide depth information, i. e. the z-axis and may be, further on, subjected to magnification errors. Plaster casts created with impressions taken from the lip would result on surface distortions due to compression of soft tissues and dimensional changes of the impression or cast material. Furthermore, obtaining lip impressions are a time consuming and difficult task requiring considerable corporation from patients. It was possible to avoid all the aforesaid drawbacks in this study by employing the stereophotography technique. The 3-D image acquisition is fast, not causing discomfort to patients. As these images are in 1:1 ratio with the size of the patient, it can be used as a 3-D virtual impression of the face.

Repeated identification of a single landmark is needed when performing multiple measurements with manual anthropometry. The resulting landmark identification errors would be especially relevant to the orolabial area which contains mobile soft tissue that would be further affected by varying nature of the lip posture. However, as the capture speed of the stereophotography system is extremely fast with approximately 1.5 milliseconds, such measurement errors due to postural changes of the lips can be minimized. Furthermore, as anthropometric landmarks in this study were located only once on the 3-D image, errors from repeated landmark identification could be avoided.

The spatial position of upper and lower lips may change depending on the facial expression. Thus immediately before the images were taken, patients were instructed not to smile but maintain a neutral expression while looking at a mirror placed in front of them. Nevertheless, reproducibility of the same lip pose is a challenge which could ultimately affect the measurements. This problem is common to other quantification techniques including manual anthropometry, 2-D photography, cephalometry and plaster casts. To date there is no technique that could avoid such errors.

In conclusion, this study established orolabial anthropometric norms for Chinese young adults. Significant gender differences were noted in the linear dimensions but not for the proportional indices. The norms established here can be used in the objective evaluation of lips during diagnosis, treatment planning and longitudinal assessment of treatment outcomes.

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Figure 1.
Orolabial anthropometric landmarks used in this study.

Figure 2. Distribution of orolabial anthropometric measurements in males across three different ethnic groups

Figure 3. Distribution of orolabial anthropometric measurements in females across three different ethnic groups

Table 1

Definitions of anthropometric landmarks used in this study.

Landmark	Definition
Subnasale (sn)	The midpoint of the angle at the columella base where the lower border of the nasal septum and the surface of the upper lip meet ¹⁰
Labiale superius (ls)	The midpoint of the vermilion line of the upper lip ¹¹
Crista philtri (cph)	The point at each elevated margin of the philtrum just above the vermilion line ¹⁰
Cheilion (ch)	The point located at each labial commissure ¹⁰
Stomion (sto)	The midpoint of the labial fissure when the lips are closed naturally ¹¹
Labiale inferius (li)	The midpoint of the lower vermilion line ¹⁰
Sublabiale (sl)	The midpoint of the Labiamental sulcus ¹¹
Pogonion (pg)	The most anterior midpoint of the chin ¹⁰

Table 2
Normative orolabial measurements for Chinese young adults

Measurement	Gender	Mean	SD	P-value
Mouth width (ch-ch)	Male	49.70	3.72	< 0.001
	Female	45.18	3.52	
Philtrum width(cph-cph)	Male	12.80	1.83	< 0.001
	Female	11.14	1.34	
Upper lip height (sn-sto)	Male	23.39	2.66	< 0.001
	Female	21.50	1.97	
Cutaneous upper lip height (sn-ls)	Male	15.45	2.41	0.016
	Female	14.37	2.02	
Upper vermilion height (ls-sto)	Male	10.20	1.85	0.002
	Female	9.09	1.69	
Lower vermilion height (sto-li)	Male	10.98	1.59	< 0.001
	Female	9.79	1.64	
Cutaneous lower lip height(li-sl)	Male	11.10	2.63	0.002
	Female	9.55	2.25	
Lower lip height(sto-sl)	Male	19.48	2.61	< 0.001
	Female	17.40	1.96	
Labiomental angle (li-sl-pg)	Male	138.94	13.48	0.314
	Female	141.27	9.57	
Interlabial angle (sn-ls/li-sl) *	Male	61.75	14.12	0.046
	Female	56.93	9.53	

* New measurements

Table 3
Normative orolabial proportions

Proportion	Gender	Mean	SD	P-value
Lip height index (sto-sl/sn-sto $\times$ 100) [†]	Male	83.94	11.83	0.319
	Female	81.60	11.85	
Upper vermillion-cutaneous lip index (ls-sto/sn-sto $\times$ 100) *	Male	67.737	16.7	0.362
	Female	64.768	16.18	
Lower vermillion-cutaneous lip index (sto-li/sto-sl $\times$ 100) *	Male	104.99	32.41	0.491
	Female	109.74	37.2	
Upper lip height mouth width index (sn-sto/ch-ch $\times$ 100) *	Male	47.33	6.55	0.663
	Female	47.86	5.79	
Lower lip height mouth width index (sto-sl/ch-ch $\times$ 100) *	Male	39.453	6.38	0.576
	Female	38.786	5.68	

* New proportion

[†] The traditional name has been changed