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Morphometric Norms of The Craniofacial Complex of Sri Lankans

Arambawaata AKS, Peiris HRD, Banneheka BMHSK, Nandasena TGLN, Abeysundara RGAP, Ihalgedera DD, Dissanayake M.

Department of Basic Sciences, Faculty of Dental Sciences, University of Peradeniya.
E mail Address: aksa@dental.pdn.ac.lk; akasaarambawatt818@gmail.com

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Abstract: Normative data for the measurements of the craniofacial complex for a given population are indispensable to precise determination of the degree of the deviation from the normal. The study group consisted of 624 healthy young subjects of all ethnic groups of Sri Lankans, 250males and 374 females of 18-30 years of age using a multistage stratified cluster sampling. The slandered anthropometric measurements were taken to determine the morphologic characteristics of the craniofacial complex. There were no significant differences of dimensions among any of the ethnic groups ;Sinhala, Tamil & Muslims, except Calva height (v-tr) of males, and special upper facial height (g-sn) and head width (pp) of females in the head region. In face, special upper face height (g-sn) was highly significant in females ($P<0.05$) while labio-oral region mouth width (ch-ch) was highly significant in males.All the craniofacial measurements except Skull height (n-v), Upper facial height/total nasal length (n-sn), forehead height (g-tr), total facial height (gn-n) Nasal root (mf-mf), Alar length (ac-prn), and Columella length (c-sn) are highly significantly different between male and female, Except forehead height 1 (g-tr), Skull height (n-v), Upper facial height/total nasal length (n-sn), Nasal root (mf-mf), Nasal width (al-al), tip protrusion (sn-prn), all other dimension were showed significant differences among provinces. The measurements from this study can provide the basic framework for establishment of craniofacial dimensions for Sri Lankan population which are crucial in anthropological studies as well as clinical set up for diagnosis and treatment planning needs for Sri Lankan adults.

Keywords: Anthropometry, Craniofacial, Norms, Sri Lankans

Introduction

The craniofacial complex comprising the calvarium, cranial base and the facial skeleton with the associated teeth, constitutes an important anatomic region, both functionally

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and aesthetically. Normative data for the measurements of the craniofacial complex for a given population are indispensable to precise determination of the degree of the deviation from the normal.

Measurement of the craniofacial complex was first performed by Ancient Greeks and the great Renaissance scholars, Da Vinci, Bergmuller, Druer and Elsholtz who developed the neofacial proportion canons (Borman etal 1999, Bozkir et al 2004, Wang et al 1997). These 400-year old canons regarded as the precursors of the present day anthropometric proportion indices, greatly influenced the plastic, aesthetic and maxillofacial surgeons of the last century when restoring the normal features of a disfigured face using reconstructive surgery (Broadbent and Matthews 1957, Tolleth 1987).

When morphometric/anthropometric methods were introduced into clinical practice to quantify changes in the craniofacial framework, features distinguishing various races/ethnic groups were discovered (Farkas et al 2005, Porter and Olson 2001, Borman et al 1999, Hajnis et al 1994, Johansdottir et al 2004). Later morphometric studies testing the validity of these neoclassical facial canons in healthy North American Caucasians (Farkas et al 2004), Asian populations (Le et al 2002), Chinese populations (Wang et al) and several other population groups (Farkas et al 2005) revealed that a set of standard values cannot be accepted as valid guides during reconstructive surgery.

As disfigurement due to congenital malformations and trauma are common in the region of craniofacial complex, surgeons are often encountered with corrective and reconstruction surgeries to restore the normal features of this region. For successful treatment of such congenital deformities and post-traumatic disfigurement the surgeon requires access to craniofacial databases based on accurate anthropometric measurements. Such data are indispensable in evaluating the craniofacial abnormalities and several systemic syndromes (Treacher Collins syndrome, Crouzon-Apert syndrome etc.), pre-surgical intervention planning and postsurgical evaluation of malformed craniofacial features and pre-surgical intervention planning and postsurgical evaluation of trauma patients (Farkas et al 2002, 2005).

Cosmetic surgery in Sri Lanka in the past was a rarity due to non availability of facilities and trained and competent surgeons. Patients with such disfigurement due to trauma or congenital deformities were compelled to bear the difficulties due to functional and aesthetic impairment. However, with heightened awareness of the newer trends in surgery among the community of Sri Lanka and the social stigma associated with such disfigurement the scenario is now changing with more and more patients seeking corrective and reconstructive surgery of this region.

Measurements of the craniofacial complex together with those of the dental arches and teeth are highly relevant in the clinical practice to the orthodontist and

the prosthodontist. Further, they are a critically important component to the forensic scientist in the victim identification process (Solheim 1993, Soomer et al 2003, Vystrcilova and Novotny 2000). In cases of unknown bodies, age estimation becomes essential when no ante-mortem information is available and a personal profile has to be reconstructed. Such cases often include bodies that are mutilated or severely decomposed, either in single cases or mass graves, such as can be seen in a post war conflict areas or disaster scenes. These data are also valuable in the identification and age estimation in precious archaeological skeletal remains dating back hundreds of years. In cases of living persons, if the person cannot provide acceptable identification documents the odontometric data will be useful in the age estimation. Such cases often include refugees and illegal immigrants who have arrived in a country without any legal documents.

Data pertaining to morphometry of the craniofacial component (Farkas et al 2005, Porter and Olson 2001, Borman et al 1999, Johansdottir et al 2004) and teeth (odontometry) (Flower 1985, Kondo et al 2001, Kondo and Townsend 2004) are available for most population groups. Such data for Sri Lankans have scarcely been discussed. The earliest thorough analysis on the physical anthropology of the Sri Lankan was reported by Stoudt (1961) based on the data collected by Marett between 1937 and 1939 during an ethnological survey of Sri Lankans. This report includes standard anthropometric measurements along with craniofacial morphological measurements and dental variations such as eruption times, tooth size, dental crowding and caries. In this study the sample consists of males only and no landmark definitions are given for any of the measurements taken. The data are crudely assembled with no quantitative assessment. For example, tooth eruption is judged as complete or incomplete, while tooth size was reported as large, medium or small.

With reference to craniofacial complex the only recent study available to date is that of Nanyakkara and Chandrasekera (1998) where measurements for seven craniofacial parameters are reported for the pre-adolescent and adolescent children Sri Lankans. In the absence of craniofacial and odontometric databases based on accurate morphometric measurements on a representative sample of Sri Lanka including all ethnic groups, the clinicians and forensic scientists are compelled to use normative data established for other population groups. Racial and ethnic morphometric differences in the craniofacial complex have been the focus of many investigators (Farkas et al 2005, Porter and Olson 2001, Borman et al 1999, Hajnis et al 1994, Johansdottir et al 2004) and these studies have revealed the urgent need for population specific normative data for such morphometric measurements.

Therefore the present study aims to establish normative data for the measurements of the craniofacial complex and to determine the variations in above dimensions with gender and ethnic variation in Sri Lankan Population which are of great national relevance.

Materials and Methods

Selection of the sample

As the study aims to establish normative data for Sri Lankans, the sample was collected from all the provinces except Eastern provinces of the island using a multistage stratified cluster sampling. From each district, 2-3 Grama Niladari Divisions (GNDs) were selected on a random basis.

The study group consisted of 624 healthy young subjects, 250males and 374 females of 18-30 years of age.

Inclusion criteria of the subjects included in this study were: age between 18-25 years, normal craniofacial configuration, normal occlusion (defined as a condition in which each arch is bilaterally symmetrical, the anterior maxillary segment is slightly larger than the corresponding mandibular segment, and each maxillary tooth contacts with its corresponding mandibular agonist and its distal neighbor (Farkas 1994) and no known history of craniofacial congenital anomaly, craniofacial surgery or trauma, developmental disability or any neurological disorder.

After getting the written informed consent, which was approved by the Ethical Review Committee, Faculty of Dental Sciences (FDS-FRC/2014/11) brief record of the socio demographic background to ascertain the age, sex, date of birth, period of residence in the district, etc. was obtained and documented. The ethnicity of each individual was also confirmed by three generation pedigree.

The following anthropometric measurements were taken to determine the morphologic characteristics of the craniofacial complex (Farkas 2005).

Head

- occipito-frontal circumference (o-f)
- head breadth (occi-g)
- Head width (p-p)
- Skull height (n-v)
- Calva height (v-tr)

Face

- Facial width/bizygomatic distance (zy-zy)
- forehead height 1 (g-tr)
- forehead height 2 (n-tr)
- Upper facial height/total nasal length (n-sn)
- Special upper facial height (g-sn)
- Total facial height (gn-n)
- Lower facial height (sn-gn)

Nose

- Nasal length (n-prn)
- Nasal root (mf-mf)
- Nasal width (al-al)
- Alar length (ac-prn)
- Columella length (c-sn)
- tip protrusion (sn-prn)

Labio-oral region

- mouth width (ch-ch)
- lower lip thickness
- Total lip thickness

Orbit

- inter ocular/Intercanthal distance (en-en)
- outercanthal distance (ex-ex)
- Eye fissure width (ex-en)

Ear

- Ear length (s-sba)

Techniques and Instruments

All craniofacial measurements were performed using standard anthropometric instruments (digital sliding calipers, digital spreading calipers, etc.). Measurement techniques and landmark definitions described by Farkas (2005) were adopted during this study. (Figure 1,2,3,4)

Each measurement was taken by two investigators after training throughout the study to avoid any inter examiner error and the average was considered. The intra examiner error was tested by repeating the measurements randomly after three months and comparing the two for any significant difference.

Figure 1

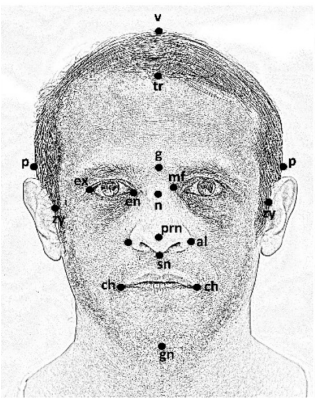

Figure 2

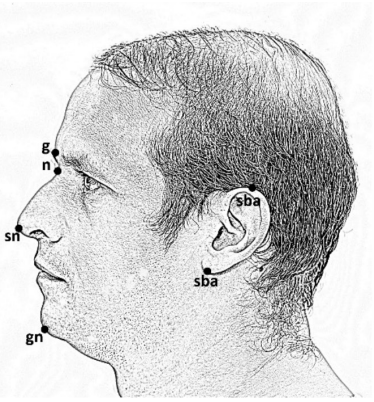

Figure 3

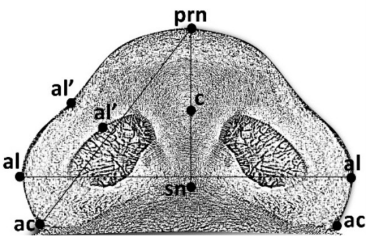

Figure 4

Results

The craniofacial measurements of three ethnic groups; Sinhala, Tamil & Muslim, are summarized in table 7. There were no significant differences in the dimensions tested

among ethnic groups except Calva height (v-tr) of males, and special upper facial height (g-sn) and head width (pp) of females in the head region. In face, special upper face height (g-sn) was significant in females ($P<0.05$) while abio-oral region mouth width (ch-ch) was highly significant in males .

Head

In males and females the occipito-frontal circumference (o-f), head breadth (occi-g), head width (p-p), calva height (v-tr) showed significant variation among different provinces, while Skull height (n-v) does not show any variation among provinces in females. Highest values for occipito-frontal circumference (o-f) were observed in western (in males) and northern (in females) province, while smallest o-f values were observed in Uva (in males) and southern (in females) province. Head breadth (occi-g) value was highest in Northwewestern (in females) and Western (males), and lowest in Uva both females & males). Head width (p-p) was highest in Northwestern (in females) and Sabaragamuwa (in males) province, while smallest in northwestern (in females) & Uva (in males) province. In females, highest n- v values were observed in western province. Lowest n-v was recorded in Uva (in females) and southern (in males) province. Largest Calva height (v-tr) values was observed in Uva (in males & females) while smallest v-tr was observed in Sabaragamuwa (in females) and North central (male) province (**table 1**).

Facial region

In males, the Facial width/bizygomatic distance (zy-zy), total facial height (gn-n), Special upper facial height (g-sn), and Lower facial height (sn-gn) showed significant variation among provinces while forehead height 2 (n-tr), g-sn, and sn-gn showed significant variation among provinces in females . Meanwhile, forehead height 1 (g-tr), upper facial height/total nasal length (n-sn), did not show any significant variations among provinces in both sexes. Of the seven facial measurements of the face, highest values for transverse dimension (zy-zy) were observed in Northwestern (in females), and Uva (in males) province and lowest were observed in central (in both sexes) province. In vertical measurements highest values were seen in forehead height 2 (n-tr) in females of North central Province, while lowest n-tr was seen in Uva province. In males, highest n-tr values were observed in Northcentral province while lowest value was recorded in Sabaragamuva province. Highest values for Special upper facial height (g-sn) were observed in central (in females) and Uva (in males)

province and lowest in western (in females) and central (in male) province. Highest values for lower facial height (sn-gn) were observed in Northern (for both sexes) and lowest values were seen in Uva (both sexes) province. In females, highest value for n-sn was observed in northwestern and lowest was seen in Northern province. In males, highest value was observed in Northwestern and lowest in Sabaragamuwa province. Highest forehead height values (g-tr) were seen in Northcentral (in female) and central province (in males), while lowest values were observed in Uva (female) and Sabaragamuwa (males) (**Table 2**).

Nose

It was observed that Alar length (ac-prn) of both sexes was significantly difference among provinces having the highest values in northern (in females), and western (in males) and the lowest values in Uva province (in females), and north central province (in males). In females, Nasal length (n-prn) and Columella length (c-sn), showed significant differences among provinces . However, in males. Nasal length (n-prn), Nasal root (mf-mf), Nasal width (al-al), and tip protrusion (sn-prn) did not show any significant differences among provinces **(table 3).**

Labio-oral region

Mouth width (ch-ch), lower lip thickness values were highly significant among provinces in both sexes having the widest lip in Northwestern (in females) and central (in males) province and the narrowest lips in North central in both sexes. However, in males total lip thickness was highly significant having the highest values in northwestern and the lowest in southern province. In females, highest total lip thickness was observed in Northcentral and lowest in Sabaragamuwa province **(table 4).**

Orbit

Interestingly, no significance differences were observed in any of the dimensions of the eye for both sexes among different provinces. **(table 5).**

Ear

No significance differences were observed in Ear length (s-sba) in both sexes among different provinces **(table 6).**

Table 1: Head

Province	*Gender*	*Measurement*				
		o-f	*occi-g*	*p-p*	*n-v*	*v-tr*
Central (n=79)	Male *(n=37)*	55.04±1.97	182.36± 7.37	147.76 ± 7.31	105.04±10.03	41.31± 9.91
	Female *(n=42)*	54.09±1.89	175.35 ±7.69	145.45±5.74	104.97±8.67	40.84±10.79
North Central (n=95)	Male *(n=40)*	54.20±2.20	182.62±8.14	145.96±7.51	104.19±10.33	40.90±10.48
	Female *(n=55)*	53.61±1.65	173.88±6.90	140.64±6.28	104.62±8.48	38.82±8.37
Uva (n=68)	Male *(n=28)*	52.48±1.60	171.25±6.76	141.58±6.08	105.43±10.09	52.49±16.37
	Female *(n=40)*	53.82±1.63	179.58±8.02	145.90±5.28	103.86±9.50	56.69±20.26
Northwestern (n=68)	Male *(n=43)*	53.68±1.57	173.86±6.39	147.50±6.00	106.88±9.91	41.40±10.96
	Female *(n=25)*	53.92±3.49	179.20±8.86	148.09±5.43	106.56±10.70	45.22±10.44
Western (n=174)	Male *(n=52)*	55.62±1.31	187.52±7.45	151.83±4.66	109.48±10.48	43.85±11.76
	Female *(n=122)*	53.64±1.57	174.69±7.10	145.22±5.51	107.42±10.11	43.70±10.58
Southern (n=73)	Male *(n=28)*	55.45±1.37	183.47±7.62	151.51±6.10	102.28±9.26	41.32±12.42
	Female *(n=45)*	53.56±1.44	173.59±6.53	143.97±3.96	105.84±9.47	41.58±9.94
Sabaragamuwa (n=35)	Male *(n=11)*	55.31±1.92	180.83±8.26	152.81±7.12	109.61±13.18	48.35±13.41
	Female *(n=24)*	53.76±1.57	174.33±5.42	146.60±7.54	104.64±7.73	38.32±6.58
Northern (n=30)	Male *(n=11)*	54.65±1.08	182.51±4.38	152.15±5.65	106.34±9.15	43.62±13.06
	Female *(n=19)*	54.23±1.27	178.10±6.50	145.95±6.96	105.35±9.69	41.93±9.12
Difference among provinces	Male	0.000	0.000	0.000	0.058	0.000
	Female	0.000	0.033	0.000	0.592	0.000

Occipito-frontal circumference (o-f), head breadth (occi-g), Head width (p-p) Skull height (n-v), Calva height (v-tr)

Table 2: Face

Province	*Gender*	*Measurement*						
		zy-zy	*g-tr*	*n-tr*	*n-sn*	*g-sn*	*gn-n*	*sn-gn*
Central (n=79)	Male *(n=37)*	115.89±10.79	60.87±8.38	69.12±9.25	48.71±4.63	57.56±4.99	109.84±10.37	65.27±9.07
	Female *(n=42)*	116.70±7.49	58.88±7.02	69.21±7.60	49.01±5.83	59.88±11.71	105.01±6.91	60.66±3.66
North Central (n=95)	Male *(n=40)*	119.34±9.28	60.61±10.16	69.80±11.04	49.16±4.67	58.47±5.25	107.90±9.22	63.65±7.03
	Female *(n=55)*	119.35±10.87	60.29±8.11	71.07±8.43	47.88±6.29	56.21±3.16	102.62±12.33	61.03±3.83
Uva (n=68)	Male *(n=28)*	125.67±6.60	59.25±9.66	68.30±7.88	49.91±4.23	62.05±7.29	110.95±10.58	63.09±6.26
	Female *(n=40)*	121.22±7.06	55.00±11.39	64.62±10.99	48.58±5.83	55.82±6.85	102.49±8.83	59.31±7.36
Northwestern (n=68)	Male *(n=43)*	125.17±9.85	59.91±6.02	70.73±6.57	51.05±5.57	60.67±6.01	112.59±7.75	66.29±5.15
	Female *(n=25)*	122.05±7.38	58.77±8.18	68.92±8.72	51.12±5.63	57.75±4.20	106.25±7.75	62.09±6.54
Western (n=174)	Male *(n=52)*	123.18±7.95	60.12±8.99	70.08±9.26	49.96±4.47	58.50±4.74	112.60±7.52	67.08±5.61
	Female *(n=122)*	118.67±7.35	57.38±8.53	66.59±7.44	49.81±6.56	55.48±3.89	103.62±5.87	60.93±4.44
Southern (n=73)	Male *(n=28)*	120.79±6.05	60.59±11.15	69.86±12.50	50.65±4.33	60.22±3.98	112.61±7.57	65.51±6.58
	Female *(n=45)*	117.14±6.37	58.01±8.89	67.47±8.18	50.00±6.65	55.99±3.99	105.74±5.82	61.98±5.02
Sabaragamuwa (n=35)	Male *(n=11)*	123.39±8.47	54.93±6.93	65.07±6.35	46.69±2.70	57.74±1.54	112.67±3.28	66.61±3.06
	Female *(n=24)*	118.66±6.71	57.84±5.02	69.39±8.21	48.85±5.59	57.74±4.26	104.29±4.89	60.41±4.11
Northern (n=30)	Male *(n=11)*	124.29±5.47	59.76±7.09	68.26±9.54	49.59±4.39	58.47±3.49	116.17±5.55	71.26±6.28
	Female *(n=19)*	120.97±5.59	57.32±8.09	66.21±7.43	47.20±3.19	56.26±4.75	107.68±7.13	63.96±4.78
Differences among provinces	Male	0.000	0.722	0.757	0.110	0.010	0.053	0.009
	Female	0.037	0.208	0.007	0.197	0.003	0.064	0.021

Facial width/bizygomatic distance (zy-zy), forehead height 1 (g-tr), forehead height 2 (n-tr), Upper facial height/total nasal length (n-sn), Special upper facial height (g-sn), Total facial height (gn-n), Lower facial height (sn-gn)

Table 3: Nose

Province	*Gender*	*Measurements*					
		n-prn	*mf-mf*	*al-al*	*ac-prn*	*c-sn*	*Sn-prn*
Central (n=79)	Male *(n=37)*	44.74±9.97	21.49±3.08	37.39±1.19	32.30±6.63	14.30±0.56	18.36±2.77
	Female *(n=42)*	42.16±9.37	21.55±3.32	36.41±1.91	31.94±8.61	14.34±2.27	17.68±2.44
North Central (n=95)	Male *(n=40)*	40.59±5.08	21.71±3.21	36.88±1.61	28.59±7.09	14.53±0.20	17.91±1.95
	Female *(n=55)*	37.73±4.12	22.74±3.39	35.81±1.55	32.78±9.69	14.52±0.38	17.05±1.95
Uva (n=68)	Male *(n=28)*	44.55±7.89	20.35±3.14	36.67±1.72	30.64±6.09	14.34±0.61	17.85±1.79
	Female *(n=40)*	39.47±4.46	22.58±3.29	35.67±1.88	29.80±7.33	14.40±0.43	17.62±2.01
Northwestern (n=68)	Male *(n=43)*	43.19±5.27	22.21±3.83	37.04±1.56	29.97±6.48	14.38±0.57	17.57±1.51
	Female *(n=25)*	41.59±3.48	21.16±3.46	35.70±1.85	36.32±9.11	14.41±0.40	17.53±2.06
Western (n=174)	Male *(n=52)*	43.30±64.34	21.47±2.93	37.37±1.29	36.17±8.18	14.33±0.56	17.58±2.03
	Female *(n=122)*	39.96±3.65	21.61±3.30	36.06±3.68	33.57±9.46	14.44±0.37	17.32±2.10
Southern (n=73)	Male *(n=28)*	44.37±3.58	21.84±3.18	36.60±1.41	35.47±8.07	14.37±0.49	18.83±3.00
	Female *(n=45)*	41.47±3.85	21.33±3.36	35.96±1.72	34.71±9.41	14.49±0.25	17.06±2.13
Sabaragamuwa (n=35)	Male *(n=11)*	42.40±2.46	21.62±2.86	36.20±2.09	34.72±9.14	14.45±0.15	17.06±0.73
	Female *(n=24)*	41.48±3.98	22.65±3.59	36.32±1.70	32.60±8.94	14.19±0.61	17.76±1.67
Northern (n=30)	Male *(n=11)*	42.15±4.06	22.50±3.14	36.93±1.73	34.45±7.98	14.57±0.13	18.29±1.38
	Female *(n=19)*	41.91±4.72	22.08±3.39	36.55±1.33	36.55±1.33	14.49±0.21	16.99±1.74
Differences among provinces	Male	0.087	0.440	0.089	0.000	0.448	0.126
	Female	0.000	0.201	0.415	0.045	0.036	0.612

Nasal length (n-prn) Nasal root (mf-mf) Nasal width (al-al) Alar length (ac-prn) tip protrusion (sn-prn) Columella length (c-sn)

Table 4: Labio-oral region

Province	*Gender*	*Measurements*		
		ch-ch	*Lower lip thickness*	*Total lip thickness*
Central (n=79)	Male *(n=37)*	53.18±4.75	11.26±2.46	20.62±3.07
	Female *(n=42)*	50.01±3.11	10.43±1.58	19.65±2.69
North Central (n=95)	Male *(n=40)*	49.99±5.31	11.07±1.41	20.56±2.53
	Female *(n=55)*	48.30±3.35	11.22±1.70	20.19±2.79
Uva (n=68)	Male *(n=28)*	51.77±3.97	11.43±1.96	20.55±2.50
	Female *(n=40)*	48.92±3.45	10.59±1.47	19.36±2.26
Northwestern (n=68)	Male *(n=43)*	52.37±3.71	12.67±2.09	22.77±3.30
	Female *(n=25)*	50.43±2.51	10.84±1.83	19.40±3.31
Western (n=174)	Male *(n=52)*	52.25±4.43	11.66±1.60	20.80±2.36
	Female *(n=122)*	49.86±4.27	10.77±1.51	19.29±2.62
Southern (n=73)	Male *(n=28)*	52.08±3.67	11.50±2.33	19.76±2.83
	Female *(n=45)*	48.40±3.82	10.42±1.32	18.94±2.00
Sabaragamuwa (n=35)	Male *(n=11)*	50.18±3.92	10.87±0.98	20.75±2.84
	Female *(n=24)*	48.55±4.16	10.01±1.26	18.55±1.96
Northern (n=30)	Male *(n=11)*	50.89±2.82	11.74±1.62	20.50±3.36
	Female *(n=19)*	49.15±3.57	11.03±1.28	19.69±3.11
Differences among provinces	Male	0.051	0.008	0.001
	Female	0.044	0.029	0.203

Mouth width (ch-ch)

Table 5: Orbit

Province	*Gender*	*Measurements*			
		En-en	*Ex-ex*	*Ex-en Right*	*Ex-en Left*
Central (n=79)	Male *(n=37)*	33.26±3.23	102.43±10.40	34.45±4.22	34.72±4.46
	Female *(n=42)*	30.44±2.99	96.48±6.07	32.81±2.41	33.23±2.32
North Central (n=95)	Male *(n=40)*	32.26±2.71	101.00±10.18	34.49±4.62	34.26±5.23
	Female *(n=55)*	30.54±3.85	97.55±5.86	33.41±2.05	33.60±2.60
Uva (n=68)	Male *(n=28)*	32.05±2.71	99.59±5.51	33.71±2.39	33.84±2.49
	Female *(n=40)*	30.56±2.27	97.51±7.40	33.56±3.29	33.39±3.38
Northwestern (n=68)	Male *(n=43)*	32.56±2.84	101.91±5.95	34.69±.233	34.66±2.24
	Female *(n=25)*	29.87±2.72	98.35±4.45	33.99±2.34	34.49±1.49
Western (n=174)	Male *(n=52)*	30.90±2.89	100.04±5.88	34.57±2.71	34.57±2.24
	Female *(n=122)*	30.75±3.37	97.42±5.46	33.23±2.27	33.45±2.71
Southern (n=73)	Male *(n=28)*	30.91±3.97	100.04±6.05	34.44±3.14	34.70±2.75
	Female *(n=45)*	30.53±2.58	96.20±5.50	32.76±2.78	32.91±2.42
Sabaragamuwa (n=35)	Male *(n=11)*	31.16±3.20	91.71±6.42	32.74±1.91	33.81±2.38
	Female *(n=24)*	29.72±2.72	95.22±6.16	32.51±2.59	33.00±2.57
Northern (n=30)	Male *(n=11)*	31.29±3.39	100.59±4.79	34.93±1.06	34.37±1.48
	Female *(n=19)*	30.97±2.63	98.24±4.53	33.44±2.47	33.82±1.75
Differences among provinces	Male	0.008	0.529	0.662	0.954
	Female	0.798	0.444	0.325	0.367

Inter ocular/Intercanthal distance (en-en), outercanthal distance (ex-ex), Eye fissure width (ex-en)

Table 6: Ear

Province	*Gender*	*Measurements*	
		(s-sba) Right	*(s-sba) Left*
Central **(n=79)**	Male *(n=37)*	61.15±4.39	61.23±4.64
	Female *(n=42)*	58.59±3.49	58.32±9.75
North Central **(n=95)**	Male *(n=40)*	60.27±3.96	60.39±3.73
	Female *(n=55)*	57.67±4.17	57.91±4.21
Uva **(n=68)**	Male *(n=28)*	60.09±3.54	60.11±3.93
	Female *(n=40)*	56.93±9.60	57.18±3.16
Northwestern **(n=68)**	Male *(n=43)*	60.10±4.18	61.07±3.90
	Female *(n=25)*	59.22±3.85	59.44±4.28
Western **(n=174)**	Male *(n=52)*	62.61±3.62	62.77±4.10
	Female *(n=122)*	58.95±4.16	58.88±4.29
Southern **(n=73)**	Male *(n=28)*	60.27±5.28	60.66±4.75
	Female *(n=45)*	57.81±3.70	58.07±3.62
Sabaragamuwa **(n=35)**	Male *(n=11)*	61.89±4.97	61.30±4.96
	Female *(n=24)*	57.71±4.60	57.65±4.97
Northern **(n=30)**	Male *(n=11)*	60.33±3.73	59.83±3.15
	Female *(n=19)*	58.94±4.73	57.81±7.88
Differences among provinces	Male	0.105	0.092
	Female	0.079	0.336

Inter ocular/Intercanthal distance (en-en), outercanthal distance (ex-ex), Eye fissure width (ex-en)

Table 7

Ethnic group		*Sinhala*		*Tamil*		*Muslims*		*Difference among ethnic groups*	
Gender		*Male n=205*	*Female n=309*	*Male n=33*	*Female n=46*	*Male n=12*	*Female n=19*	*Male*	*Female*
Head	o-f	54.66±2.33	53.54±1.67**	54.85±1.57	53.78±1.71**	55.68±1.49	53.84±1.20*	.294	.511
	occi-g	182.63±8.60	174.03±6.82**	181.93±6.50	176.34±7.67**	185.68±5.62	172.56±6.21*	.393	.060
	p-p	148.81±6.61	144.08±6.04**	148.78±6.46	144.08±6.56**	152.88±4.27	148.59±4.92*	.108	.007
	n-v	105.47±10.84	106.04±9.56	107.61±9.18	105.81±9.51	108.71±2.84	105.11±7.54	.347	.909
	v-tr	43.36±11.83	42.13±10.78	53.45±19.07	46.99±14.15	40.96±6.85	42.75±10.85	.000	.025
Face	zy-zy	121.76±9.32	118.45±7.87**	122.11±9.24	120.58±7.07	123.63±4.03	123.86±6.55	.781	.004
	g-tr	59.77±8.90	57.91±8.40	60.43±9.19	57.85±9.93	62.46±6.57	58.57±6.90	.564	.946
	n-tr	69.30±9.45	67.81±8.30	69.20±9.28	67.04±9.72	73.31±6.15	68.82±6.79	.346	.724
	n-sn	49.59±4.71	49.32±6.29	50.27±4.82	47.96±4.91*	50.93±3.83	50.08±6.44	.500	.304
	g-sn	59.05±5.12	56.20±4.47**	60.66±7.15	55.91±4.28**	59.42±3.24	62.95±16.14	.282	.000
	gn-n	110.75±8.44	103.99±7.69**	113.24±9.78	104.74±8.87**	117.68±5.53	105.35±6.72**	.011	.657
	sn-gn	65.31±6.59	60.82±4.42**	21.12±3.08	21.98±3.27	22.12±3.00	20.55±2.73	.050	.184
Nose	n-prn	42.98±6.14	40.16±4.20**	44.37±6.76	41.19±8.99	44.31±4.31	40.74±3.63*	.399	.403
	mf-mf	21.65±3.26	21.96±3.41	21.12±3.08	21.98±3.27	22.12±3.00	20.55±2.73	.578	.205
	al-al	36.96±1.53	36.04±2.68**	37.35±1.58	36.11±1.66**	36.78±1.09	35.81±1.92	.342	.810
	ac-prn)	32.88±8.08	33.51±9.35	31.30±6.28	31.38±8.32	28.84±3.99	33.22±8.31*	.138	.340
	c-sn	14.37±0.52	14.4±30.41	14.45±0.40	14.46±2.14	14.55±0.18	14.33±0.59	.336	.517
	sn-prn	17.91±2.22	17.35±1.98**	17.86±1.78	17.53±2.68	18.32±1.65	16.80±1.71*	.801	.423
Labio-oral region	ch-ch	51.68±4.35	49.34±3.87**	53.63±3.15	49.03±3.68**	49.39±6.20	48.92±2.21	.008	.804
	lower lip thickness	11.56±1.99	10.67±1.55**	11.85±1.94	11.12±1.43	11.63±1.86	10.20±1.61	.734	.065
	Total lip thickness	20.97±2.93	19.35±2.48**	20.63±3.11	20.32±3.04	20.68±1.94	18.34±3.28*	.796	.012
Orbit	en-en	31.90±3.18	30.39±3.16**	31.82±2.70	31.31±2.69	32.33±3.74	30.93±2.38	.889	.141
	ex-ex	100.90±7.89	96.85±5.60**	100.10±5.59	99.42±6.37	99.73±4.69	96.58±5.86	.760	.017
	ex-en-Right	34.45±3.40	33.11±2.38**	34.13±2.46	34.00±3.04	33.94±2.00	32.64±2.37	.772	.047
	ex-en- Left	34.55±3.43	33.36±2.55**	34.15±2.69	34.12±2.83	33.46±2.48	33.00±2.30	.466	.134

Ear	s-sba Right	34.45±3.40	33.11±2.38**	34.13±2.46	34.00±3.04	33.94±2.00	32.64±2.37	.640	.951
	s-sba Left	34.55±3.43	33.36±2.55**	34.15±2.69	34.12±2.83	33.46±2.48	33.00±2.30	.919	.161

Occipito-frontal circumference (o-f), head breadth (occi-g), Head width (p-p) skull height (n-v), Calva height (v-tr), Facial width/ bizygomatic distance (zy-zy), forehead height 1 (g-tr), forehead height 2 (n-tr), Upper facial height/total nasal length (n-sn), special upper facial height (g-sn), total facial height (gn-n), Lower facial height (sn-gn), Nasal length (n-prn) Nasal root (mf-mf) Nasal width (al-al), alar length (ac-prn) tip protrusion (sn-prn) columella length (c-sn), mouth width (ch-ch), Inter ocular/Intercanthal distance (en-en), outercanthal distance (ex-ex), Eye fissure width (ex-en), Inter ocular/Intercanthal distance (en-en), outercanthal distance (ex-ex), eye fissure width (ex-en)

All island (n=624)				
Measurements	*Males (n=250)*	*Females (n=374)*	*p Value*	
	Mean	*Mean*		
Head				
occipito-frontal circumference (o-f)	54.74±2.22	53.58±1.65	0.0000	
head breadth (occi-g)	182.68±8.24	174.23±6.93	0.0000	
Head width (p-p)	149.00±6.54	144.31±6.12	0.0000	
Skull height (n-v)	105.90±10.41	105.97±9.44	0.9405	
Calva height (v-tr)	44.58±13.25	42.76±11.33	0.0752	
Face				
Facial width/bizygomatic distance (zy-zy)	121.90±9.11	118.98±7.81	0.0000	
forehead height 1 (g-tr)	59.98±8.83	57.93±8.52	0.0041	
forehead height 2 (n-tr)	69.48±9.31	67.77±8.40	0.0198	
Upper facial height/total nasal length (n-sn)	49.74±4.68	49.19±6.15	0.1996	
Special upper facial height (g-sn)	59.28±5.37	56.51±5.79	0.0000	
Total facial height (gn-n)	111.41±8.65	104.15±7.79	0.0000	
Lower facial height (sn-gn)	65.67±6.69	61.03±4.97	0.0000	
Nose				
Nasal length (n-prn)	43.23±6.15	40.32±5.01	0.0000	

	Nasal root (mf-mf)	21.61±3.22	21.89±3.36	0.2845
	Nasal width (al-al)	37.00±1.52	36.04±2.54	0.0000
	Alar length (ac-prn)	32.48±7.76	33.24±9.18	0.2679
	Columella length (c-sn)	14.39±0.49	14.43±0.85	0.9915
	tip protrusion (sn-prn)	17.93±2.13	17.35±2.06	0.0008
Labio-oral region				
	mouth width (ch-ch)	51.82±4.38	49.28±3.77	0.0000
	lower lip thickness	11.60±1.97	10.70±1.54	0.0000
	Total lip thickness	20.91±2.91	19.42±2.62	0.0000
Orbit				
	inter ocular/Intercanthal distance (en-en)	31.91±3.14	30.53±3.08	0.0000
	outercanthal distance (ex-ex)	100.74±7.49	97.15±5.76	0.0000
	Eye fissure width (ex-en) Right	34.38±3.23	33.20±2.48	0.0000
	Eye fissure width (ex-en) Left	34.445±3.30	33.43±2.58	0.0001
ear				
	Ear length (s-sba) Right	61.08±4.20	58.29±5.02	0.0000
	Ear length (s-sba) Left	61.13±4.20	58.29±6.80	0.0000

Discussion

Craniofacial anthropometrical measurements

Ethnic and inter province comparison

This study focused on craniofacial anthropometrical measurements of healthy Sri Lankan population having no obvious dysmorphological features and no known family history of genetic defects. Present study is intended to establish the average craniofacial parameters of the craniofacial complex of Sri Lankan consisting of six provinces with 25 measurements and to determine any morphological differences between genders, among ethnic groups and regional variations.

Gender difference has been reported in the literature (Farkas et al 2005) and therefore, it is important clinically, as well as anthropologically to have gender norms. In general, sexual dimorphism was found to be significantly high in almost all parameters in head and face. Males in general have significantly higher measurements than females in most of the craniofacial parameters. The difference between most of the craniofacial parameters can be explained by the inherited genetic lineage which is widely accepted explanation in the scientific community (Farkas et al 2005)

Meanwhile, present study has not shown any significant difference among ethnic groups except few craniofacial dimensions probably due to admixture of the population groups across the provinces irrespective of ethnic variations. Interestingly, some of the parameters of craniofacial region showed statistically significant difference among provinces. Though it is premature to come into a conclusion it may be attributed to the fact that the craniofacial dimensions are affected by ecological, biological, geographical, gender, and ethnicity which are major determining factors for head dimensions(Tuli et al., 1995; Raji et al., 2010).

Comparison with world population

Facial region: In males the Facial width/bizygomatic distance (zy-zy), total facial height (gn-n), Special upper facial height (g-sn), and Lower facial height (sn-gn) showed significant variation among different world populations. Of the seven facial measurements of the face, bizygomatic distance (zy-zy) of males and females are larger in North American white, Asian (Thai, north indian, Bangladesh, Japanese, Singaporean), Afro American, Caucasians (German, Azerbaijan, Bulgarian, Czech, Greek, Hungarian, Croatian, Italy, Portuguese, Polish, Slovak,Russia, and Middle East (Iran,Slovenian, Turkish, Egyptian) populations in compare that of Sri Lankans.

Higher upper (g-sn) and lower facial height (sn-gn) are observed in both males and females of North Americans, Japanese, Bangladesh, Tonga, Afro American, Caucasians (German, Azerbaijan, Bulgarian, Czech, Greek, Hungarian, Croatian, Italy, Portuguese, Polish, Slovak,Russia) and Middle East (Iran, Slovenian, Turkish, Egyptian) than Sri Lankans. Meanwhile, (sn-gn) of Sri Lankan males and females is in agreement with those of Indians.

Need to include references and table no

Nose: It was observed that Alar width (al-al) of both genders was variable among different world populations. In compare with Sri Lankans, alar width is wider in both genders of Asian populations such as Singaporean, Thai, Japanese, Vietnamese, and afro Americans such as tonga, Angola. Meanwhile, alar width is smaller in north American white, Bangadesh, Iran, and Egyptians than Sri Lankans while it shows close affinity with India males and females.

Furthermore, Nose height was higher in both males and females of north Americans, Azerbaijan, Bulgaria, crocaisians, iran, Egyptians, Indians, chineses, Vietnams, Thai, Japanese, Angolan, tonga, and afro Americans than that of Sri Lankans.

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Labio-oral region: Mouth width (ch-ch) is higher in North Americans, Afro-Americans of both genders. However, amongst middle Eastern population groups (Iran, Egyptian Egyptian), mouth width measurements are lower than those of Sri Lankan.

Furthermore, in Asian populations such as Indian, Singaporean, Vietnamese, Thai, and Japanese and African populations such as Angolan, Tonga the width of the mouth is wider than both Sri Lankan males and Females. In other Caucasian populations like Bulgarian, Croatian, German, Portuguese, and Iran, ch-ch distance is narrower than Sri Lankans.

Need to include references

Orbit: En-en distance of Sri Lankan males and females shows no clear difference with that of other world populations compared in the present study.

Ex-En: Ex-En distance showed wide variations among populations. It is lower in both males & females of North American White, Caucasians (Bulgaria, Czech, Croatian, German), Egyptian, Asians (Indian, Singaporean, Vietnamese, Thai, Japanese) and African (Angola, Tonga) populations than Sri Lankans. On the other

hand, it is wider in both male and female of Hungarian, Portuguese, Russian, Greek, Slovak, Slovenian, Iran than Sri Lankans.

Ex-Ex: Ex-Ex distance was lower in both males & females of North American White, Azerbaijan, Bulgarian, Czech, Croatian, German, Greek, Italian, Polish, Portuguese, Russian, Iran, Turkish, Egyptian, Angola than Sri Lankans. However, it is wider in males and narrower in females of Japanese and Tonga populations than Sri Lankans while wider in females and narrower in males of India, Singaporean, Vietnamese, Thai, and Hungarian than Sri Lankans.

Ear

sa-sba: sa-sba shows higher values for both males and females of North American White, Azerbaijan, Bulgarian, Czech, Croatian, German, Greek, Hungarian, Polish, Russian, Slovak, Slovenian, Iran, Turkish, and Asian populations such as Thai, Japanese. Sa-Sba distance was lower in both males & females of Portuguese, Singaporean, Angolan, and Tonga than Sri Lankans.,

It is interest to reveal some differences among different Asians populations and it may be due to the genetic and environmental influences. The certain similarities and differences between different populations together with the stable characteristics of Asians can be explained only by inherited genetic factors, an explanation generally accepted by Scientists (Farkas 2005). In addition, the factors affecting the variations in facial morphometry is to be influenced by mainly socioeconomic status, and nutritional habits of the populations. (Farkas 2005). Thus, it may be concluded that besides racial and ethnic factors, geographical factor can also affect the morphometry of the face.

Conclusion

All the craniofacial measurements except Skull height (n-v), Upper facial height/total nasal length (n-sn), forehead height (g-tr), total facial height (gn-n) Nasal root (mf-mf), Alar length (ac-prn), and Columella length (c-sn) are highly significantly different between male and female, Except forehead height 1 (g-tr), Skull height (n-v), Upper facial height/total nasal length (n-sn), Nasal root (mf-mf), Nasal width (al-al), tip protrusion (sn-prn), all other dimension were showed significant differences among provinces.

No significant difference in craniofacial dimensions was observed among ethnic groups; Sinhala, Tamil & Muslims, except head width (p-p) in females, Calva height (v-tr) in males Special upper facial height (g-sn) in females, and mouth width in males.

The measurements from this study can provide the basic framework for establishment of craniofacial dimensions for Sri Lankan population which are crucial in anthropological studies as well as clinical set up for diagnosis and treatment planning needs for Sri Lankan adults.

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