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Facial Anthropometric Norms of a Young Adult Jordanian Population

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ABSTRACT

Objectives: This study aimed at establishing and analyzing the first database of facial anthropometric norms specific to a Jordanian population and presenting these norms in a form available for orthodontists and surgeons to use them for managing their patients.

Materials and Methods: Frontal and lateral digital photographs were obtained from 470 young adult Jordanians (317 males and 153 females aged 18-40 years). Sixteen facial parameters (6 frontal and 10 lateral parameters) were measured digitally using a custom-designed computer program. Means and standard deviations were calculated for all the measured variables and Students' t-tests were used to calculate the sex differences on the one hand and the age- and sex-specific differences between the studied sample (the Jordanians) and 3 other population groups: Northern Americans, Chinese and African Americans, on the other hand.

Results: Except the facial convexity, all measured parameters had statistically significant sex differences, with the males exhibiting higher mean values. The studied Jordanians are different in many of the facial parameters from people belonging to other populations. In general, The Jordanians, especially males, have greater facial dimensions and variations than the other populations in comparison.

Conclusions: The study established the first facial anthropometric database specific for young adult Jordanians. The provided norms will be useful for orthodontists, orthognathic surgeons, plastic surgeons and dysmorphologists in aiding the diagnostic facial recognition of variations and deviations from normal, as well as in planning, performing and following-up treatment

Keywords: Face, Anthropometry, Norms, Jordanian population.

1. Introduction

Qualitative assessment of facial features is a key element in the clinical practice of genetics, syndromoloy, police sciences and in maxillofacial plastic and orthognathic surgeries. Although qualitative assessment of normal and deviated facial features may present some challenge for beginners, the robustness of its employment in clinical practice is improved through years of expertise in clinical practice, which may be attained when the physician's eye becomes trained on observing more accurately due to the long term use of quantitative measures (1). In other words, training on clinical anthropometry[1] is essential to improve the outcomes of qualitative anthroposcopy[2]. One limitation of clinical anthroposcopy is evident in its inability to distinguish between disharmony and disproportion (1). These two correlated, but distinct, clinical signs have then to be delineated by objective measures.

[1] Anthropometry is the branch of the human sciences that deals with body measurements (7).

[2] Anthroposcopy is the determination of human bodily characteristics by inspection as opposed to exact measurements in anthropometry (7).

Before evaluating facial anthropometric findings, valid norms specific to the race, sex and age need to be available (1). Although the literature may be replete with such databases (2-19), earlier works published by Farkas (recognized as father of modern craniofacial anthropometry[3]) in 1994 (7) remain the most elaborative and standardized ones warranting their reliability.

An orthodontist employs both anthroposcopy and anthropometry for the diagnostic, operative and follow-up care of their patients. The first diagnostic impression derived from the patient's facial gestalt, overall skeletal relationship, facial heights and facial proportions is built on anthroposcopy. Yet, this needs confirmation through direct and cephalometric objective assessments, that are attained through measuring facial, skeletal and dental parameters (anthropometry). In summary, an orthodontist relies on qualitative measures for initial assessment that lead to tentative or provisional diagnoses and quantitative measures for confirmed diagnoses, operative assessment and maintenance.

In the field of orthodontics, the availability of objective description of human face through anthropometric facial norms is of great benefit for any orthodontist aiming at attaining an eventual soft-tissue facial outcome consistent with the acceptable normal facial proportions of the population of the patient (6). Despite later works on individual populations and ethinc groups (2-5, 8, 11, 13, 17-19), the craniofacial norms published by Leslie Farkas in the mid-nineties remain the most comprehensive and standardized norms, as they were derived from large groups of individuals from three distinct ethnic groups (7). Farkas' database was structured based on examining craniofacial parameters in 3 distinct major ethnic groups: North American, African American and Chinese. The database has been successfully used as a reference in specialized clinical practice and anthropometric research.

Studies utilizing facial norms and facial measurements have been widely conducted (7-19). The majority of such studies functioned in providing the literature with population-specific facial norms. On the other hand, a collection of other studies investigated the facial measurements in application to some specific clinical practice, such as orthodontics, orthognathic surgery and dysmorphology in craniofacial malformation (20-25).

While restoring the normal appearance is the main goal in reparative surgery, the ultimate aim of aesthetic surgery is to create at least an average face which demands attention to proportionality (1). Quantification of normal facial parameters in a population leads to the establishment of databases that demonstrate the normal facial measurements and their variation-in-normal for that particular population (26-31). Such databases may function in providing normal facial quantitative data for the surgeon to utilize for the surgical adjustment of facial elements according to aesthetically and functionally acceptable normal parameters.

At present, facial anthropometric assessment of individual patients in Jordan is performed against reference normative means, standard deviations and ranges specific to other populations (for example, the Western populations). To the best of our knowledge, there has not been any databases of facial norms published for the Jordanian population which would have functioned as normative references that can be utilized for the care of individual Jordanian patients. Therefore, the present study is anticipated to provide the first database of facial norms specific to adult Jordanians, which can be made available for practising clinicians in Jordan. Such a database will not only aid the accurate diagnostic assessment and planning treatment in various clinical disciplines, but will also allow for assessment of treatment outcomes and follow-up, in addition to its potential use in craniofacial anthropometric research.

2. Materials and Methods

A convenient sample of 470 young adult Jordanian participants (living in Irbid Governorate) participated in the study. The sample consisted of 317 males and 153 females in the age of 18-40 years. All participants were healthy individuals who had neither had any condition or illness that would affect their growth and development nor had any bone, calcium or metabolic disorders. The participants had not had any craniofacial

[3] https://www.ajodo.org/article/S0889-5406(09)00952-4/pdf

defects related to malformations, accidents or corrective surgeries. All participants were Jordanian citizens and were residents of north Jordan. The sample was a convenient sample selected from the outpatients who were regularly visiting the Dental Teaching Clinics of Jordan University of Science and Technology (JUST). The inclusion and exclusion criteria insured the purity of the studied population and its lack of any condition or illness that would change its craniofacial features. Before taking part in the study, participants were provided with printed information statements to read and consent forms to sign. The study received the financial support of the Deanship of Scientific Research and the approval of the Institution of Research Board of Jordan University of Science and Technology (number 20080119).

Two photographs, one frontal and one left lateral, were obtained from each participant. The photography set-up consisted of an 8 mp Canon Digital Ixus camera (Lens 35-mm equiv., zoom, aperture 28-105 mm (3.8×) f/2.8-5.8) assembled on a tripod, a standard A3 graph sheet based on millimetric square units and 25 centimetric square units as well as a 300-mm plastic ruler fitted on the background wall. A height-adjustable backless stool was used for seating the subjects.

Photographs were captured with the following standardized conditions:

- Room illumination with artificial fluorescent lighting.
- The graph sheet was fitted on the wall with its lower edge elevated 1 meter above and parallel with the floor.
- The camera-tripod assembly was adjusted so that the platform of the tripod was brought horizontal with the lens of the camera opposing the midface region of the seated participant.
- The lens of the camera was set 120 cm away from the wall-mounted graph sheet for the frontal photography and 135 cm for the lateral photography. This brought the plane of the measured parameters roughly about 1 meter in front of the camera, leaving a distance of 20 cm and 35 cm between the plane of the measurements and the graph sheet for the frontal and lateral captures, respectively. The choice of 20 cm and 35 cm was not decided arbitrarily. A number of participants were asked to sit on the stool and have their heads touching the graph sheet and then, the distance between the sheet and the nasion point was measured. For those participants, it was found that the average of all of those distances was nearly 20 cm. For the lateral views, the average distance between the sheet and midsagittal profile was 35 cm, which allowed room for the participants' right shoulders.
- For both the frontal and lateral captures, the head was adjusted according to the natural head position, since none of the frontal parameters required adjusting the head according to the standard Frankfurt Horizontal Plane. The natural head position was defined by Lundstrom et al. (32) as "*The head orientation of the subject perceived by the clinician based on general experience as the resting head position in relaxed body and head posture (with the lips closed and relaxed), when the subject is looking at a distant point at eye level and the visual access is parallel to the floor*".

A computer program named 'JUST' was used to prepare the captured images and interactively perform the facial measurements (Figure 1 and Figure 2). All measurements were calibrated against horizontal, vertical and diagonal scales drawn digitally on the background graph-sheet part of the photographic image through designating 3 of the 4 angles of a 25-cm square unit. Using the principles of geometry, the approximated scales on the plane of the measured parameters were calculated and recorded, considering the pre-known distances of the camera to the plane of measurements and the graphic background.

The next step was to designate the anthropometric facial landmarks on the frontal and lateral images. Utilizing the landmarks, 16 different parameters were measured. Table 1, Figure 1 and Figure 2 show the landmarks used and the parameters measured on the frontal and lateral photographs.

Table 1: The parameters measured in this study together with their identifying landmarks

Parameter	Landmarks used	Landmark definitions	Image
Inner canthal distance	en-en	**en**: endocanthion: The point at the inner commissure of the eye fissure	Frontal
Inter pupillary distance	Pupil point	Midpoint of pupil when the eye looks straight forward	Frontal
Outer canthal distance	ex-ex	**ex**: exocanthion: The point at the outer commissure of the eye fissure	Frontal
Tragal width	t-t	**t**: tragus	Frontal
Alar width	al-al	**al**: alare: The most lateral point at each alar contour	Frontal
Mouth width	ch-ch	**ch**: cheilion: The point located at each labial commissure	Frontal
Upper facial height	tr-g	**tr**: trichion: The point on the hairline in the midline of the forehead. **g**: glabella: The most prominent midline point between the eyebrows	Lateral
Middle facial height	g-sn	**g**: see above. **sn**: subnasale: 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	Lateral
Lower facial height	sn-me	**sn**: see above. **me**: menton (gnathion): The lowest median landmark on the lower border of the mandible	Lateral
Aesthetic line[1] – upper lip distance		The shortest distance between the midline point of the vermilion border of the upper lip to the aesthetic line	Lateral
Aesthetic line – lower lip distance		The shortest distance between the midline point of the vermilion border of the lower lip to the aesthetic line	Lateral
Facial convexity	g-sn-pg angle	**g**: see above. **sn**: see above. **pg**: pogonion: The most anterior midpoint of the chin	Lateral
Nasiolabial angle[2]	Angle between columella-sn line and midphiltrum line	**sn**: see above	Lateral
Labiomental angle[3]	Angle between lower vermilion-sm line and tangent on the anterior convexity of the chin	**sm**: submentale: The point of greatest concavity in the midline of the lower lip between labrale inferius and pogonion.	Lateral
Nose angle[4]	Angle between n-outline of nose line and collumella-sn line	**n**: nasion: The point in the midline of both the nasal root and the nasofrontal suture. **sn**: see above	Lateral
Mandibular inclination[5]	Angle between me-go line and or-t line	**me**: see above. **go**: gonion: The most lateral point on the soft tissue contour of each mandibular angle. **or**: orbitale: The lowest point on the lower margin of each orbit. **t**: see above	Lateral

[1] Aesthetic line (of Ricketts) is an imaginary line running through the tip of the nose (pronasale) and the prominence of the chin (soft-tissue pogonion).

[2] The angle between two straight lines; the first is running along the collumella of the nose and the second along the midportion of the philtrum of the upper lip. These two lines meet in the subnasale.

[3] The angle between two straight lines; the first runs from the midline point of the vermilion border of the lower lip running through the submentale and the second line is a tangent on the anterior convexity of the chin running through the submentale.

[4] The angle formed between two lines; the first passes along the outline of the nose from the nasion point, and the second along the columella of the nose from the subnasale.

[5] The angle between two lines extending to meet posterior to the head. The first runs between the soft-tissue menton and the soft-tissue gonion. The second runs between the orbitale and the tragus of the ear.

The next step was to designate the anthropometric facial landmarks on the frontal and lateral images. Utilizing the landmarks, 16 different parameters were measured. Table 1, Figure 1 and Figure 2 show the landmarks used and the parameters measured on the frontal and lateral photographs.

Figure 1: The parameters measured on the frontal view

Figure 2: The parameters measured on the lateral view

The software allowed exporting all measurements per parameter collectively to a Microsoft Excel Spreadsheet for descriptive and inferential statistical analyses.

All measurements were carried out by one examiner (HA). The intra-examiner error was calculated according to Dahlberg's formula through repeating the 16 measurements on randomly-selected 15 frontal and 15 lateral images and comparing the new measurements with the original ones.

Two-sample unequal variance two-tailed Student T-test was carried out between males and females per parameter. The level of significance was set at ($p \leq 0.05$). For each of the measured parameters, age-and sex-specific z-scores were calculated with reference to the corresponding parameters (if available) for the three population groups (Northern Americans, African Americans and Chinese) published in Farkas' database (7).

Not all of the sixteen parameters measured in our study were available in the Farkas' database (7) to calculate z-scores. The Northern-American data lacked 4 parameters (aesthetic line-upper lip distance, aesthetic line-lower lip distance, facial convexity and mandibular inclination). For the African Americans and the Chinese population groups, we were only able to calculate z-scores for 5 parameters (inner and outer canthal widths, tragal width, alar width and mouth width).

The value of a z-score describes in standard deviation units the deviation of the mean of a given measurement from the mean of the matched population. A z-score can be positive or negative, reflecting the direction of difference.

Paired T-tests were used to calculate the statistical significance of the differences between our measurements and the corresponding ones of the matched populations. The level of significance was set at ($p \leq 0.05$).

3. Results

3.1 Intra-examiner Error

Table 2 presents the intra-examiner error for the parameters measured. The average error for the linear parameters was 1.9 mm and for the angular parameters 9.21°.

Table 2: Intra-examiner error per parameter

Linear parameters	Intra-examiner error (mm)	Angular parameters	Intra-examiner error (°)
Intercanthal distance	1.67	Facial convexity	10.81
Intercanthal distance	2.12	Nasiolabial angle	8.81
Outercanthal distance	3.12	labiomental angle	13.86
Tragal width	3.81	Nose angle	9.4
Alar width	1.51	Manibular inclination	3.19
Mouth width	1.92		
Upper face height	1.44		
Middle face height	1.46		
Lower face height	1.48		
Aesthetic line-upper lip	1.57		
Aesthetic line-lower lip	0.85		
Average error	**1.9**	**Average error**	**9.21**

Table 3: Means, standard deviations and mean differences between sexes and their statistical significance

Parameter	Males n=317 Mean±SD	Females n=153 Mean±SD	Mean Difference
Inner canthal distance (mm)	41.0±5.4	34.9±1.6	6.0***
Interpupillary distance (mm)	77.3±7.9	71.4±3.0	5.9***
Outer canthal distance (mm)	113.7±11.6	106.5±1.7	7.2***
Tragal width (mm)	162.7±14.5	147.9±9.3	14.8***
Alar width (mm)	50.3±6.5	43.6±4.9	6.7***
Mouth width (mm)	66.5±8.3	60.0±2.6	6.5***
Upper face height (mm)	55.4±7.6	48.2±5.2	7.2***
Middle face height (mm)	79.0±8.9	71.4±4.2	7.6***
Lower face height (mm)	85.0±10.2	73.0±6.5	12.1***
Aesthetic line-upper lip (mm)	7.1±3.2	6.0±1.3	1.1***
Aesthetic line-lower lip (mm)	4.2±3.2	3.7±0.8	0.6*
Facial convexity (°)	172.4±6.6	171.8±8.0	0.6$^{(NS)}$
Nasiolabial angle (°)	99.8±12.8	95.9±6.9	3.9***
Labiomental angle (°)	124.1±15.4	118.7±12.0	5.4***
Nose angle (°)	90.6±8.7	88.5±3.9	2.1*
Mandibular inclination (°)	29.6±4.3	26.8±0.6	2.8***

NS= Not significant, *=P<0.05. **=P<0.01. ***=P<0.001.

3.2 Anthropometric Facial Norms

Table 3 presents the means and standard deviations of the measured parameters for males and females and the statistically significant differences. Except the facial convexity, all measured parameters had statistically significant sex differences, with males exhibiting higher mean values. In addition, females generally showed smaller variation (evident from their lower standard deviation values) for all the measured parameters except for the facial convexity, which showed the opposite.

Table 4: Means and standard deviations of 12 of the parameters of Jordanians in contrast to those of corresponding ones of Northern Americans, Chinese and African Americans for both sexes separately

Parameter	Means and Standard Deviations for Males			
	Jordanians n=317	Northern Americans n=109	Chinese n=30	African Americans n=50
Inner canthal distance (mm)	41.0±5.4	33.3±2.7	37.6±3.3	35.8±2.8
Interpupillary distance (mm)	77.3±7.9	66.9±2	-	-
Outer canthal distance (mm)	113.7±11.6	91.2±3	91.7±4.0	96.8±4.6
Tragal width (mm)	162.7±14.5	146.8±5.6	151.8±5.3	143.4±6.1
Alar width (mm)	50.3±6.5	34.9±2.1	39.2±2.9	44.1±3.4
Mouth width (mm)	66.5±8.3	54.5±3	48.3±6.8	54.6±4.1
Upper face height (mm)	55.4±7.6	57±7.4	-	-
Middle face height (mm)	79.0±8.9	61±7.95	-	-
Lower face height (mm)	85.0±10.2	72.6±4.5	-	-
Nasiolabial angle (°)	99.8±12.8	99.8±11.8	-	-
Labiomental angle (°)	124.1±15.4	113.5±20.7	-	-
Nose angle (°)	90.6±8.7	71.7±7.4	-	-
	Means and Standard Deviations for Females			
	Jordanians n=153	**Northern Americans n=200**	**Chinese n=30**	**African Americans n=50**
Inner canthal distance (mm)	34.9±1.6	31.8±2.3	36.5±3.2	34.4±3.4
Interpupillary distance (mm)	71.4±3.0	62.6±1.8	-	-
Outer canthal distance (mm)	106.5±1.7	87.8±3.2	87.3±5.2	92.9±5.3
Tragal width (mm)	147.9±9.3	138.3±4.9	141.9±5	136.1±4.7
Alar width (mm)	43.6±4.9	31.4±2	37.2±2.1	40.1±3.2
Mouth width (mm)	60.0±2.6	50.2±3.5	47.3±3.3	53.6±4
Upper face height (mm)	48.2±5.2	52.7±6	-	-
Middle face height (mm)	71.4±4.2	59.3±7.1	-	-
Lower face height (mm)	73.0±6.5	64.3±4	-	-
Nasiolabial angle (°)	95.9±6.9	104.2±9.8	-	-
Labiomental angle (°)	118.7±12.0	121.4±14.4	-	-
Nose angle (°)	88.5±3.9	67.4±7.4	-	-

3.3 Results with Reference to Published Norms of Other Population Groups

Table 4 illustrates the males' and females' means and standard deviations of 12 measurements for the Jordanians, matched against corresponding measurements of Northern Americans, Chinese and African Americans published in Farkas' database of craniofacial norms. Except for nasolabial and upper facial height parameters, Jordanian males exhibited higher values and greater variations for the compared parameters. The nasiolabial angle was very similar between Jordanians and Northern Americans. For Jordanian females, the mean values of the upper facial height, nosolabial and labiomental angles were notably smaller than the corresponding ones of the Northern American females. The means of the inner canthal distance of Jordanian females were smaller than those of Chinese females. The rest of the compared parameters exhibited higher mean values for Jordanian females than those of the other studies' populations groups.

It is apparent that Jordanian females showed greater variations in some parameters and less variations in other parameters than those of the compared populations, while in Jordanian males, in general, there were higher variations in most of the values of the parameters than those of the compared populations.

3.4 Z-scores of the Jordanian Measurements against the Corresponding Measurements of North Americans, Chinese and African Americans

Table 5 presents the z-scores of the measured Jordanian parameters against the corresponding parameters of the North Americans, Chinese and African Americans.

Table 5: Z-scores and statistically significant differences of the Jordanian measurements against the corresponding ones of the Northern Americans, Chinese and African Americans

Parameter	Matched with North Americans				Matched with Chinese				Matched with African Americans			
	Males		Females		Males		Females		Males		Females	
	Z-score	SS	Z-score	SS	Z-score	SS	Z-score	SS	Z-score	SS	Z-score	SS
Inner canthal distance (mm)	2.85	***	1.37	***	1.03	***	-0.49	**	1.85	***	0.16	NS
Interpupillary distance (mm)	5.20	***	4.86	***	-	-	-	-	-	-	-	-
Outer canthal distance (mm)	7.51	***	5.85	***	5.50	***	3.70	***	3.68	***	2.57	***
Tragal width (mm)	2.84	***	1.96	***	2.05	***	1.20	***	3.16	***	2.52	***
Alar width (mm)	7.35	***	6.10	***	3.84	***	3.05	***	1.83	***	1.09	***
Mouth width (mm)	4.00	***	2.81	***	2.68	***	3.86	***	2.91	***	1.61	***
Upper face height (mm)	-0.21	*	-0.75	***	-	-	-	-	-	-	-	-
Middle face height (mm)	2.26	***	1.71	***	-	-	-	-	-	-	-	-
Lower face height (mm)	2.76	***	2.17	***	-	-	-	-	-	-	-	-
Nasiolabial angle (°)	0.003	NS	-0.84	***	-	-	-	-	-	-	-	-
Labiomental angle (°)	0.51	***	-0.19	*	-	-	-	-	-	-	-	-
Nose angle (°)	**2.56**	*******	**2.86**	*******	-	-	-	-	-	-	-	-

SS= Statistically significant. NS= Not significant. *=P<0.05. **=P<0.01. ***=P<0.001.

Across many of the parameters, the z-scores indicate positive differences in favor of Jordanian males compared to males belonging to the other population groups. These were more evident in the outer canthal width, followed by the alar width, interpupillary distance and the mouth width. On the other hand, for other parameters, there were smaller positive differences or even negative ones. Examples of the former are the nasolabial angle and the labiomental angle and an example of the latter is the upper facial height. The mean nasiolabial angle is only a fraction of millimeters larger in Jordanian males than that for the Northern Americans.

The differences between Jordanian males and the males of the other population groups showed heightened statistical significance across all the corresponding parameters, except for the nasolabial angle. For the upper facial height, the difference was just statistically significant.

In contrast, the z-score for females were smaller than those for males. The alar width, outer canthal width and interpupillary distance presented the highest positive z-scores in favor of Jordanian females in comparison with the others. On the contrary, the upper facial height, nasolabial and labiomental angles showed high negative z-scores (positive in favor of other population groups).

Except for the inner canthal distance between Jordanian and African American females, the differences showed heightened statistical significance in favor of Jordanian females. Compared with North American females, the mean difference was just statistically significant for the labiomental angle.

4. Discussion

The findings of the present study will enrich the literature with anthropometric facial norms specific to a young Jordanian population. The published data is expected to be usefully utilized by orthodontists, orthognathic surgeons, plastic surgeons and dysmorphologists in aiding the diagnostic facial recognition of variations and deviations from normal and in planning, performing and following-up treatment in orthodontics, orthognathic surgery, plastic surgery and dysmorphology. Therefore, upon publishing such norms, clinicians will no longer need to refer to previously published data of other population groups.

One limitation of the present study is that the purposely written software was not experimentally validated before the measurements were performed on the images. However, an intra-examiner reliability test was performed and yielded reasonably small errors (an average of 1.9 mm for the linear measurements and of 9.21° for the angular parameters). A thorough discussion of all potential errors is presented below.

The approach that we followed in this study was 2-D photogrammetric. In contrast to direct anthropometry, 2-D photogrammetry allows for faster and easier measurements. However, a major concern with 2-D photogrammetry is the dimensional distortion and projection errors caused by magnification, especially when the distance between the object and the camera is short (35).

By rescaling the image dimensions, errors are controlled and reduced. It is noticed that the majority of the frontal parameters were measured on planes within a thin facial volume very close to the 20 cm of distance from the background sheet. The only exception was the tragal width, which is a few centimeters closer to the sheet. Concerning the lateral parameters, all of them were measured within the sagittal plane, which makes the choice of 35 cm an appropriate one.

The distances of 20 cm and 35 cm from the planes of measurements and the background graph sheet may still be considerable and cannot be ignored, as this could increase the potential effect of magnification and lens barrel distortion errors. The employment of geometry principles by the computer program 'JUST' to rescale the measurements and geometrically adjust them in accordance to the distances between the standardized graphic background and planes of measurements had greatly reduced the potential for such errors.

It is noteworthy that the potential for projection, distortion and digital scaling errors only applies mainly to linear distances. The angles (thought as to function as proportions or combinations of two linear measurements), on the other hand, are less likely affected (38-39) and are thought to be more accurate than the distances. Another approach that would have circumvented the errors of projection is through the use of indices and proportions.

The comparisons made against other population groups raise little concerns regarding the different measurement approaches, where the Jordanian data was obtained from photographs and the published data for the other compared population groups was obtained directly on the participants. We were unable to find previously-published 2-D photogrammetric norms derived from large samples with which the norms of this study could be matched. Nevertheless, the approach followed in our study is somehow beneficial in highlighting how accurate photogrammetry could be in contrast to direct anthropometry. This was done previously in a number of studies (35-37). Furthermore, direct anthropometry still has its drawbacks when measurements are performed with errors in designation of landmarks and taking direct measurements with soft-tissue compression.

Errors in measurements are not entirely attributed to the 2-D photogrammetry. There may still be errors caused by some imprecision in landmark designation. However, all the measurements were performed by one investigator (HA) with a low intra-examiner error value. On the frontal view, where all parameters were linear distances, the intra-examiner error was found to range from 1.51 mm to 3.81 mm. The smallest was for alar width and the highest was for tragal width. This can be attributed to the following reasons:

- First, landmark designation was obviously easier to perform when the parameter was confined to the central area of the face, such as the alar width, mouth width and intercanthal width. For those parameters, it is generally accurate to designate the landmarks, because the surface of the face tends to be relatively flat (coronal) in contrast to the side of the face (sagittal). For parameters the landmarks of which are located on the side of the face, such as the tragal width, identifying the landmarks presents a potential difficulty. Taking the tragus point as an example reveals that it tends to be hidden behind the side burns and fat cheeks of many males. This accounts to the result that the error was relatively high in the tragal-width measurements.

- Second, the side of the face on a frontal image tends to be more readily distorted than the central face, because the former is more affected by projection errors, as it is steeper and located backward in respect to the camera, which could account for some considerable error in the tragal-width measurements.

It is fair that the intra-examiner error values for the parameters measured on the lateral view are discussed separately for angles and distances. For the angles, the error was generally high, because measuring any angle requires designating 3 landmarks, in contrast to designating only 2 landmarks for linear distances. On the other hand, the errors for the angles on the lateral views were smaller than those on the frontal views, since all the parameters on the lateral views were measured between points located on one plane (midsagittal plane). This also accounts for the smaller variations in the error values across the parameters of the lateral views in contrast to those in the frontal views.

The present study reports statistically significant differences between males and females in all the measured parameters, except for facial convexity. For all the parameters, males showed higher values than females, which means that Jordanian males had logically larger facial dimensions than Jordanian females, which is consistent with what had been previously reported (7).

For many of the parameters, there were large positive differences for Jordanian males compared with males in other population groups. The largest positive difference was in the outer canthal width, followed by the alar width, interpupillary distance and the mouth width. As comparisons were provided as z-scores, the larger positive differences for Jordanian males could be due to the smaller denominator values (smaller standard-deviation values or smaller variations) in the other population groups rather than large mean differences between Jordanians males and males in the other populations.

On the other hand, there were negative z-scores in some parameters, signifying that Jordanian females have slightly smaller dimensions or more acute angles for those parameters. These include the upper facial height, nasolabial and labiomental angles.

The significance of the z-scores in determining the direction of the difference cannot be overestimated. It is apparent that z-scores not only indicate a difference, but also provide information about the amount of difference and in which direction (larger / smaller for distances and more obtuse / more acute in angles). However, z-scores lack the capability of indicating whether the difference is statistically significant; hence, paired test is needed to detect the statistical significance of the differences between the Jordanian data and the data of the other populations.

The findings of the paired t-tests indicate anthropometric differences between the Jordanians' norms and those of the other populations. The only exception was the nasolabial angle between Jordanian males and Northern American males and the inner canthal width between Jordanian females and African American females. Such differences might be attributed to several factors, such as the different ethnic background, age or method of measurement.

5. Conclusions

This study has established the first facial anthropometric database specific to young adult Jordanians. The Jordanian males and females are different in many of the facial parameters and the Jordanians differ in many of the parameters from people belonging to other populations. In general, Jordanians, especially males, have greater facial dimensions and variations than males in the other populations.

The provided norms are useful for orthodontists, orthognathic surgeons, plastic surgeons and dysmorphologists in aiding the diagnostic facial recognition of variations and deviations from normal and in planning, performing and following-up treatment in orthodontics, orthognathic surgery, plastic surgery and dysmorphology.

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Conflict of Interests

The authors report no conflict of interests.

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