Aswan University Medical Journal, volume 5 / No.2/ June 2025 (58-74) Online ISSN: **2735-3117**

# ORIGINAL ARTICLE

# Facial metrics as diagnostic tools for sex determination in Upper Egypt population

**Randa Hussein Abdel-hady[1], Heba Atia Yassa[1], Marina Mikhail Boktor[2*] and Ayman Latif Fahim[2].**

[1] Department of Forensic Medicine and Clinical Toxicology, Faculty of medicine, Assiut university

[2] Department of Forensic Medicine and Clinical Toxicology, Faculty of medicine, Aswan University.

## ABSTRACT

**Keyword**: anthropology, facial metrics, Nubian parameters, upper Egyptian metrics.

[*] **Corresponding author**: Marin Mikhail Boktor Abdel-malak, **Mobile : : 01288361972, E-mail**: marina.boktor@med.aswu.edu.eg

**Background:** Anthropometry is the science of measurements on biological objects including humans. Forensic anthropology is a unique field for research. It meets the growing desire for an efficient technology in biological meets. Bulk and form developmental variations represent an ontogenetic path in the adult development. The first exporter for data about the person is facial look that gives idea about the race and sex. **Objectives:** the aim of work is establishment of craniofacial anthropometric norms for Nubian and NNUEs (Non-nubian young egyptians) in upper Egypt using the measurements to estimate sex and calculation of the cut-off point to reach the most accurate measurements. **Methodology:** Measurements of nineteen facial parameters of 213 healthy young upper Egyptian and Nubian volunteers aged 18-23 years without history of racial parentage and analyzed by SPSS version 20. **Results:** according to cut-off point among all volunteers, the accuracy data were highest in neck circumference, bi-tragion chin arc and nose protrusion and lowest in maximum frontal breadth. **Conclusion:** the measurements in NNUEs are close to the Middle East and different from European populations while Nubians` measurements were close to Negros.

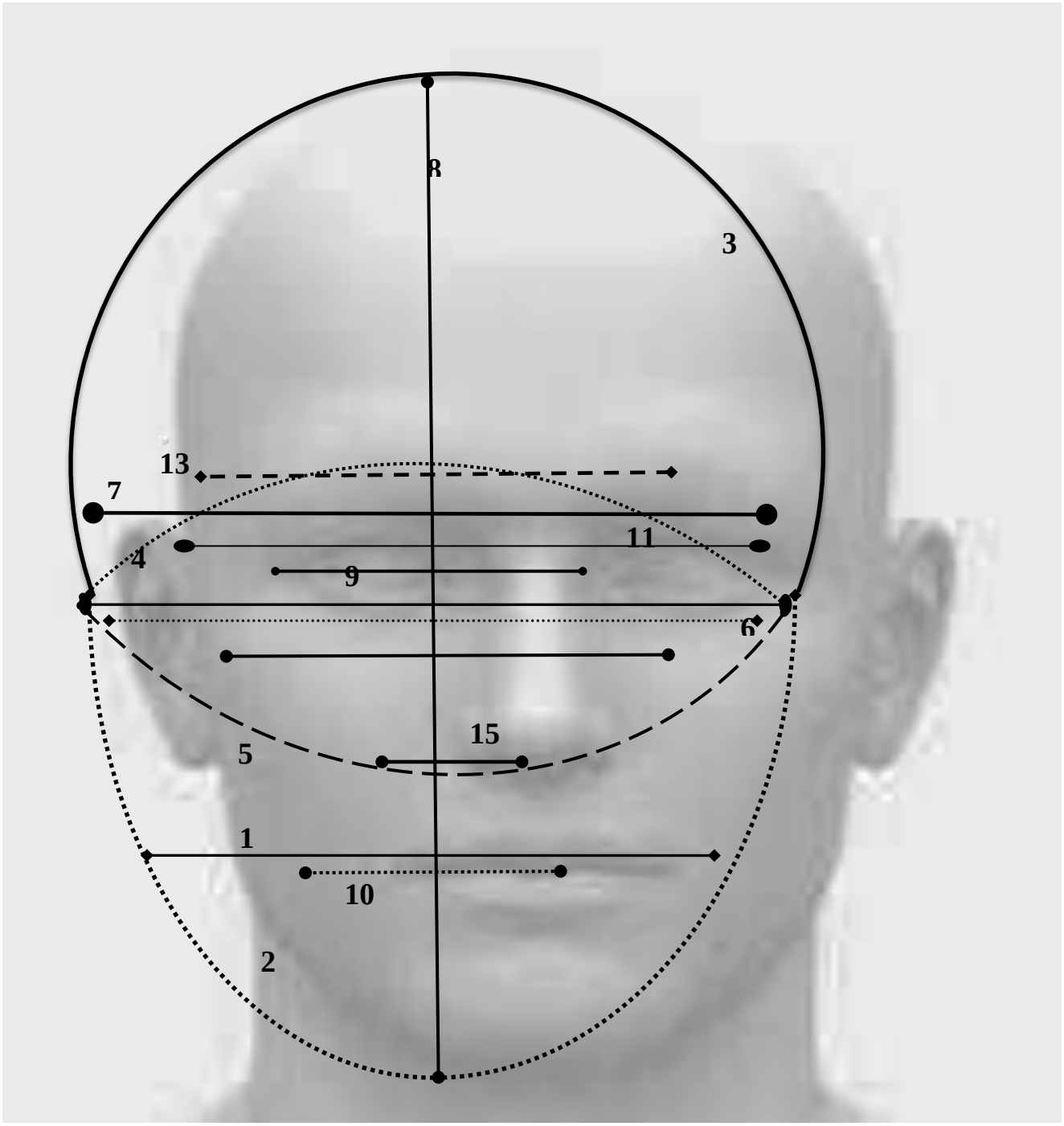
## INTRODUCTION

Identification of dead bodies is an axial element to link missed persons to specific manner of death (criminal or not ) and separate criminal cases to find murders and non-criminal ones for civil issues [1]. Skeletons collected all over the world are used as materials for building up identification profiles for different nations [2]. The face represents the first source used in identification of humans [2]. Computer technology programs have useful biometrics for discovering the persons' identity based on face recognition, feature extraction and classifier selection [4]. Facial features has an important part in figuring out vital data about sex, expression and race [5]. Sex estimation based on osteology uses morphological and morphometric methods with benefits and drawbacks [6]. The main pioneers considered in building up facial profile are nose, lips and chin as they show racial differences among different nations and sexes [7]. The nose represents the most visible part of the face as it occupies its center so it is considered as one of the most effective parameter in measuring facial features [8]. Very important dimensions in determining the sex are those of mandible as it is the largest and most resistant facial bone to decay after death [9]. Many studies focused on mandibular parameters to identify sex

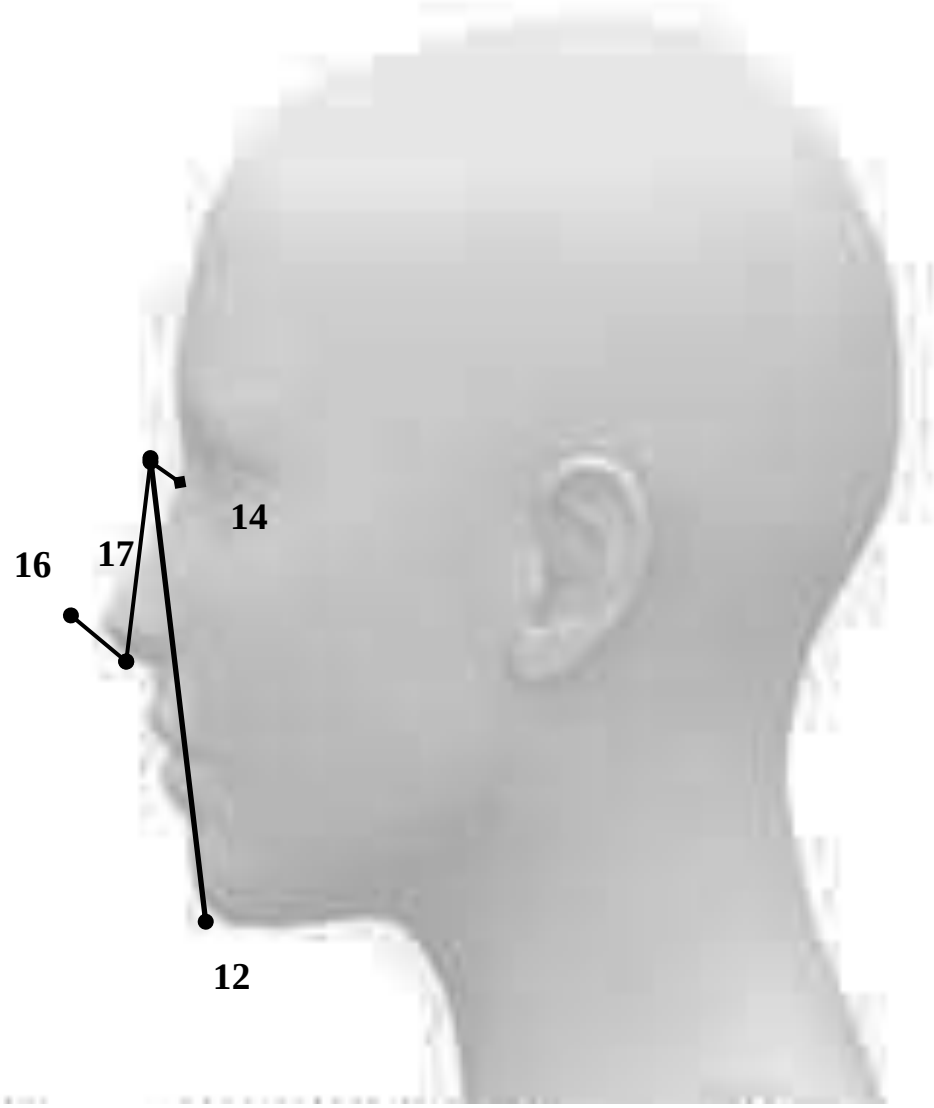
[10]. Chin shape is useful to differentiate males where it takes U shape from females as they have more V in shape [11]. The IPD (inter-pupillary distance) is affected by age, race and sex so, it is utilized by many anthropologists for differentiating purposes [12].

## SUPJECTS AND METHODS

The study was conducted in Upper Egypt over a period of one year (from 1st August 2020 to 31st July 2021). It has been designed to study the anthropometric measurements of young adults in Upper Egypt. This study spot a light on the measurements of Nubian young population as they are considered as an integral part of Aswan inhabitants. The measurements were taken from upper Egypt young non-nubian volunteers (NNUEs) in Aswan university and from the Nubian volunteers in Nubian villages in west of Aswan**.** The analyzed sample consisted of 213 healthy volunteers. **Both sexes** {101 males (19 Nubian and 82 upper Egypt not Nubian) and 112 females (13 Nubian and 99 NNUEs)}, from Upper Egypt adult population.




{19}




{20}

**1. Bi-gonial breadth**
**2. Bi-tragion chin arc**
**3. Bi-tragion coronal arc**
**4. Bi-tragion frontal arc**
**5. Bi-tragion subnasal arc**
**6. Face width**
**7. Head breadth**
**8. Head length**
**9. Inter-pupillary distance**
**10. Lip length**
**11. Maximum frontal breadth**
**12. Face length**
**13. Minimum frontal breadth**
**14. Nasal root breadth**
**15. Nose breadth**
**16. nose protrusion**
**17. Nose length**
**18. head circumference**
**19. Neck circumference**

**Inclusion criteria:**

Range : **18-23** years old**.**

With no history of racial parentage.

**Exclusion criteria**

Prior to the study, all volunteers were examined for scars or facial deformities. Those with a history of craniofacial or nasal surgery, facial trauma or congenital nose or craniofacial anomalies (such as cleft lip) that could affect the morphology of the nose had excluded.

None of these subjects exhibited any signs of facial dysfunction or facial deformity. All subjects were familiarized with the measurements to reduce bias. Each linear measurement was taken twice before it was recorded.

**Ethical considerations**

**Confidentiality:**

The confidentiality of all participants participated in this study was protected.

**Research statement:**

All ethical aspects related to research on volunteers in Aswan university were implicated in this study. According to the rules of Aswan university faculty of medicine with ethical approval number20/90474.

**Informed consent:**

Signed informed consent form volunteers were taken after complete exploration for the study. This is a permanent part of the participant's study records and were maintained in the same manners as other records.

**Instruments used:**

- Sliding caliber

 {21}

- Measuring tape

{22}

- Manual Pupillometer

{23}

**Statistical analysis:**

Data collected and analyzed using tables and charts. All statics were done by using SPSS program version 20, and the data was compared using **(t test)**.

To make a sex discrimination, cut-off value was performed for each of the 19 linear facial measurements and accuracy was figured out . The values equal to or more than the cut-off value indicate a male volunteer while those less than the cut-off value indicate a female.

**RESULTS**

**Total number of cases :**213 ( 101 males and 112 females).

**Nubians**: 32 ( 19 males and 13 females).

**NNUEs**: 181 ( 82 males and 99 females).

**Table 1 & Fig.1: Comparison of different measures (19 linear parameters) in Nubian and NNUE**

| | **n=(32) Nuba** | **n=(181) NNUE** | **P. value** |
|---|---|---|---|
| | **Mean±SD** | **Mean±SD** | |
| Bi-gonial Breadth | 7.97±0.91 | 8.22±1.34 | 0.317 |
| Bitragion chin arc | 29.17±1.81 | 30.27±2.37 | **0.013*** |
| Bitragion coronal arc | 33.88±1.41 | 33.71±2.1 | 0.666 |
| Bitragion supraorbital arc | 28.26±1.47 | 28.05±1.46 | 0.467 |
| Bi-tragion sub-nasal arc | 27.18±1.24 | 27.49±1.76 | 0.331 |
| Face width | 13.11±0.76 | 13.48±1.26 | 0.117 |

| | | | |
|---|---|---|---|
| Head width | 15.33±0.86 | 15.09±1.03 | 0.225 |
| Head length | 18.36±0.98 | 18.88±1.28 | **0.030*** |
| Inter-pupillary distance | 5.98±0.32 | 5.88±0.36 | 0.127 |
| Lip length | 5.78±0.86 | 5.59±0.59 | 0.106 |
| Maximum frontal breadth | 17.77±1.18 | 19.03±2.28 | **0.003**** |
| Minimum frontal breadth | 15.46±0.98 | 16.97±2.25 | **0.000**** |
| Face length | 10.02±0.57 | 10.22±0.95 | 0.265 |
| Nasal root breadth | 1.18±0.37 | 1.28±0.36 | 0.140 |
| Nose breadth | 3.34±0.44 | 3.26±2.35 | 0.855 |
| Nose protrusion | 2.18±0.4 | 2.05±0.43 | 0.131 |
| Nose length | 4.72±0.37 | 4.66±0.57 | 0.551 |
| Head circumference | 55.84±1.74 | 55.35±2.22 | 0.236 |
| Neck circumference | 34.49±3.39 | 34.11±3.74 | 0.592 |

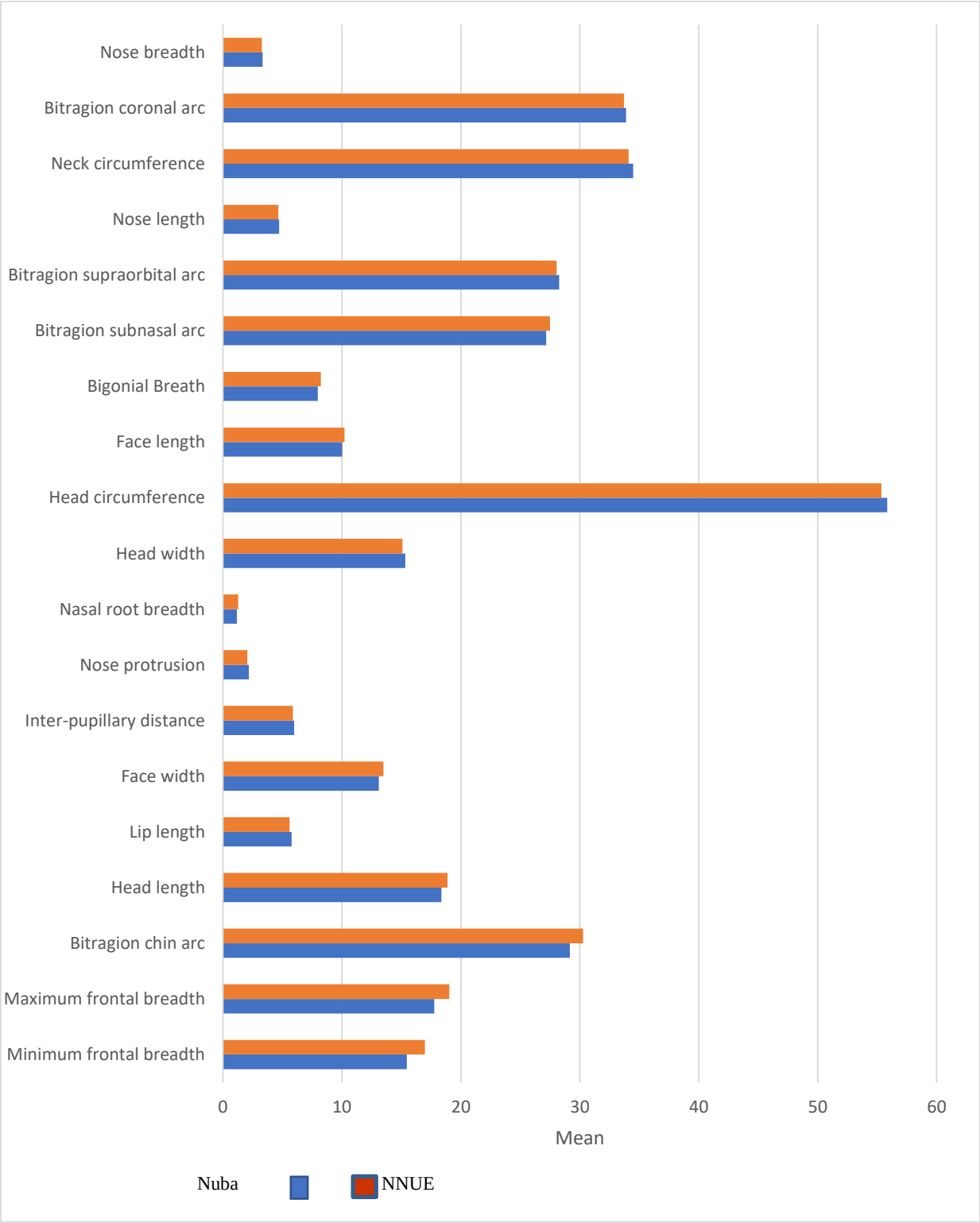



Fig.1

Significant differences are in: bi-gonial breadth (0.013*), head length (0.030*), maximum frontal breadth (0.003**), minimum frontal breadth (0.000**) (the mean is larger in NNUE volunteers in all previous measurements.

**Table 2 & Fig.2 : Comparison between Nubian males and NNUE males in the different 19 linear measurements**

| **Male** | **El nuba (n=19)** | **NNUE (n=82)** | **P. value** |
|---|---|---|---|
| | **Mean±SD** | **Mean±SD** | |
| Bi-gonial Breadth | 8.33±0.88 | 8.77±1.44 | 0.202 |
| Bitragion chin arc | 29.94±1.91 | 31.87±2.13 | **<0.001**** |
| Bitragion coronal arc | 33.86±1.52 | 34.53±2.04 | 0.179 |
| Bitragion supraorbital arc | 28.09±1.79 | 28.84±1.29 | **0.036*** |
| Bi-tragion sub-nasal arc | 27.65±1.22 | 28.51±1.48 | **0.020*** |
| Face width | 13.1±0.92 | 13.88±1.04 | **0.003**** |
| Head width | 15.4±0.85 | 15.49±1.04 | 0.718 |
| Head length | 18.55±1.04 | 19.39±1.16 | **0.005*** |
| Inter-pupillary distance | 5.92±0.33 | 6.02±0.36 | 0.248 |
| Lip length | 6.13±0.88 | 5.77±0.58 | **0.031*** |
| Maximum frontal breadth | 18.25±1.11 | 19.23±1.93 | **0.037*** |
| Minimum frontal breadth | 15.89±0.92 | 17.16±2 | **0.008**** |
| Face length | 10.13±0.59 | 10.79±0.88 | **0.002**** |
| Nasal root breadth | 1.35±0.35 | 1.42±0.32 | 0.417 |
| Nose breadth | 3.48±0.43 | 3.34±0.46 | 0.245 |
| Nose protrusion | 2.35±0.29 | 2.29±0.42 | 0.530 |
| Nose length | 4.76±0.42 | 4.85±0.55 | 0.487 |
| Head circumference | 55.47±1.77 | 56.2±1.91 | 0.128 |
| Neck circumference | 35.17±3.16 | 36.84±2.6 | **0.018*** |

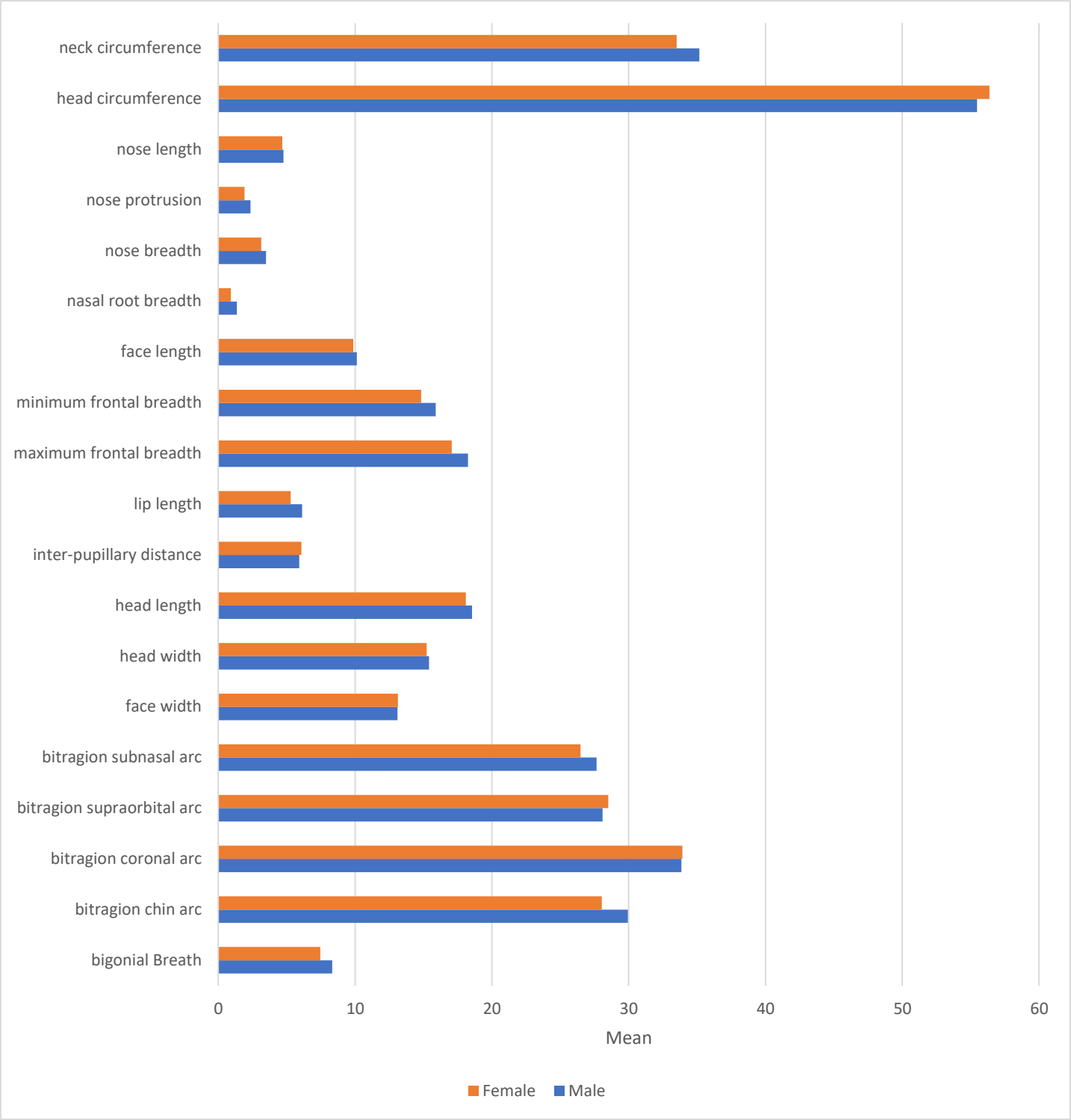



**Fig.2**

Significant differences in: bi-tragion chin arc (0.001**), bi-tragion supraorbital arc( 0.036*), bi-tragion sub-nasal arc ( 0.020*), face width ( 0.003**), head length ( 0.005*), maximum frontal breadth ( 0.037*), minimum frontal breadth ( 0.008**), face length ( 0.002**)and neck circumference ( 0.018*)

(the mean is larger in Nubian males in all previous measurements). Lip length ( 0.031*) is larger in Nubian males than NNUEs.

**Table3: Comparison between Nubian females and females of NNUE in the different 19 linear measurements**

| Female | El nuba (n=13) | NNUE (n=99) | P. value |
|---|---|---|---|
| | Mean±SD | Mean±SD | |
| Bi-gonial Breadth | 7.45±0.71 | 7.76±1.06 | 0.305 |
| Bi-tragion chin arc | 28.04±0.82 | 28.95±1.64 | 0.052 |
| Bi-tragion coronal arc | 33.92±1.29 | 33.04±1.91 | 0.111 |
| Bi-tragion supra-orbital arc | 28.51±0.85 | 27.4±1.27 | **0.003**** |
| Bi-tragion sub-nasal arc | 26.48±0.93 | 26.64±1.5 | 0.711 |
| Face width | 13.13±0.48 | 13.14±1.34 | 0.973 |
| Head width | 15.22±0.89 | 14.76±0.9 | 0.085 |
| Head length | 18.09±0.86 | 18.46±1.24 | 0.298 |
| Inter-pupillary distance | 6.08±0.29 | 5.77±0.31 | **0.001**** |
| Lip length | 5.28±0.54 | 5.44±0.55 | 0.347 |
| Maximum frontal breadth | 17.07±0.93 | 18.87±2.53 | **0.013*** |
| Minimum frontal breadth | 14.82±0.67 | 16.81±2.43 | **0.004**** |
| Face length | 9.86±0.52 | 9.74±0.72 | 0.554 |
| Nasal root breadth | 0.92±0.19 | 1.16±0.34 | **0.014*** |
| Nose breadth | 3.13±0.39 | 3.19±3.15 | 0.944 |
| Nose protrusion | 1.92±0.41 | 1.85±0.33 | 0.542 |
| Nose length | 4.67±0.3 | 4.5±0.55 | 0.277 |
| Head circumference | 56.38±1.61 | 54.63±2.22 | **0.007**** |
| Neck circumference | 33.5±3.59 | 31.85±2.95 | 0.068 |

Significant differences in: Bi-tragion supraorbital arc ( 0.003**), Inter-pupillary distance ( 0.001**) and Head circumference ( 0.007**)( the mean was larger in Nubian females in these measurements). Maximum frontal breadth ( 0.013*), Minimum frontal breadth ( 0.004**) and Nasal root breadth ( 0.014*)( the mean was lager in NNUE females in these measurements).

**Table 4: Sex discrimination using cut-off point in all examined volunteers**

| All group | cut-off | Sensitivity (%) | Specificity (%) | Accuracy (%) |
|---|---|---|---|---|
| Bigonial breath | >8.3 | 56.44 | 80.36 | 68.40 |
| Bitragion chin arc | >30.1 | 74.26 | 80.36 | 77.31 |
| Bitragion coronal arc | >33.8 | 56.44 | 72.32 | 64.38 |
| Bitragion supraorbital arc | >28.4 | 58.42 | 78.57 | 68.50 |
| Bitragion subnasal arc | >27.2 | 83.17 | 66.07 | 74.62 |

| | | | | |
|---|---|---|---|---|
| Face width | >13.2 | 66.34 | 63.39 | 64.87 |
| Head width | >14.6 | 84.16 | 48.21 | 66.19 |
| Head length | >18.4 | 77.23 | 52.68 | 64.96 |
| Inter-pupillary distance | >5.8 | 63.37 | 62.5 | 62.94 |
| Lip length | >5.6 | 56.44 | 67.86 | 62.15 |
| Maximum frontal breadth | >17.2 | 87.13 | 33.93 | 60.53 |
| Minimum frontal breadth | >15.4 | 80.2 | 43.75 | 61.98 |
| Face length | >10.4 | 60.4 | 85.7 | 73.05 |
| Nasal root breadth | >1.2 | 70.3 | 65.2 | 67.75 |
| Nose breadth | >3.1 | 67.3 | 76.8 | 72.05 |
| Nose protrusion | >1.9 | 86.1 | 66.1 | 76.10 |
| Nose length | >4.6 | 66.3 | 60.7 | 63.50 |
| Head circumference | >53.5 | 93.07 | 33.04 | 63.06 |
| Neck circumference | >34.8 | 72.28 | 84.82 | 78.55 |

The neck circumference measurement is the most distinctive measurement for sexual dimorphism with the most accuracy of (78.55) while, the least accuracy was noticed in maximum frontal breadth with accuracy of (60.53). Head circumference measurement shows the most sensitive value ( 93.07) while bitragion coronal arc and lip length measurements show the least sensitivity (56.44). Neck circumference shows the most specificity (84.82) while, the head circumference shows the least specificity (33.04).

**Table 5: Sex discrimination using cut-off point in Nubian volunteers**

| **Nuba** | **cut-off** | **Sensitivity (%)** | **Specificity (%)** | **Accuracy (%)** |
|---|---|---|---|---|
| Bigonial breath | >7.6 | 78.9 | 76.9 | 77.90 |
| Bitragion chin arc | >27.7 | 53.8 | 100 | 63.85 |
| Bitragion coronal arc | >33.3 | 78.9 | 53.8 | 66.35 |
| Bitragion supraorbital arc | ≤ 27.5 | 42.1 | 84.6 | 63.35 |
| Bitragion subnasal arc | >27.2 | 63.2 | 84.6 | 73.90 |
| Face width | >12.9 | 78.9 | 46.2 | 62.55 |
| Head width | >14.6 | 89.47 | 30.77 | 60.12 |
| Head length | >18.2 | 68.4 | 69.2 | 68.80 |

| | | | | |
|---|---|---|---|---|
| Inter-pupillary distance | ≤ 6 | 78.9 | 46.2 | 62.55 |
| Lip length | >5.3 | 89.5 | 61.5 | 75.50 |
| Maximum frontal breadth | > 17.7 | 68.4 | 76.9 | 72.65 |
| Minimum frontal breadth | > 14.8 | 94.7 | 61.5 | 78.10 |
| Face length | > 10.2 | 52.6 | 76.9 | 64.75 |
| Nasal root breadth | > 1 | 84.2 | 84.6 | 84.40 |
| Nose breadth | > 3.5 | 52.6 | 84.6 | 68.60 |
| Nose protrusion | > 1.6 | 89.5 | 69.2 | 79.35 |
| Nose length | > 4.6 | 63.2 | 53.8 | 58.50 |
| Head circumference | ≤ 55.6 | 73.7 | 69.2 | 71.45 |
| Neck circumference | > 31 | 100 | 38.5 | 69.25 |

The nasal root breadth shows the most accuracy (84.40) while the least accuracy value is in nose length measurement (58.5). The most sensitive value is neck circumference (100) while the least sensitivity is in bi-tragion supra-orbital arc. The bi-tragion chin arc shows the most specific value (100) while head width shows the least specific value (30.77).

**Table 6: Sex discrimination using cut-off point in NNUE**

| **NNUE** | **cut-off** | **Sensitivity (%)** | **Specificity (%)** | **Accuracy (%)** |
|---|---|---|---|---|
| Bigonial breath | > 8.3 | 59.8 | 78.8 | 69.30 |
| Bitragion chin arc | > 30.1 | 84.1 | 77.8 | 80.95 |
| Bitragion coronal arc | > 34.7 | 42.7 | 88.9 | 65.80 |
| Bitragion supraorbital arc | > 28.5 | 58.5 | 84.8 | 71.65 |
| Bitragion subnasal arc | > 27.2 | 87.8 | 63.6 | 75.70 |
| Face width | > 13.5 | 62.2 | 72.7 | 67.45 |
| Head width | > 14.9 | 74.4 | 60.6 | 67.50 |
| Head length | > 18.6 | 75.6 | 57.6 | 66.60 |

| | | | | |
|---|---|---|---|---|
| Inter-pupillary distance | > 5.8 | 64.6 | 67.7 | 66.15 |
| Lip length | > 5 | 95.1 | 27.3 | 61.20 |
| Maximum frontal breadth | > 17.3 | 86.6 | 33.3 | 59.95 |
| Minimum frontal breadth | > 15.4 | 82.9 | 39.4 | 61.15 |
| Face length | > 10.4 | 65.9 | 84.8 | 75.35 |
| Nasal root breadth | > 1.2 | 70.7 | 61.6 | 66.15 |
| Nose breadth | > 3.1 | 68.3 | 80.8 | 74.55 |
| Nose protrusion | > 1.9 | 85.4 | 65.7 | 75.55 |
| Nose length | > 4.6 | 67.1 | 61.6 | 64.35 |
| Head circumference | > 55 | 72 | 58.6 | 65.30 |
| Neck circumference | > 34.8 | 78 | 86.9 | 82.45 |

The neck circumference shows the highest accuracy (82.45) while, maximum frontal breadth shows the least accuracy (59.95). lip length shows the most sensitive value (95.1) while, bi-tragion supra-orbital arc shows the least sensitivity (58.5). Bi-tragion coronal arc shows the most specificity (88.9) while, the lip length shows the least specificity (27.3).

**Table7: Regression analysis for sex estimation in all group of examined volunteers**

| **All place** | **95% C.I.for EXP(B)** | | **Sig.** |
|---|---|---|---|
| | **Lower** | **Upper** | |
| Bigonial breath | 0.752 | 2.563 | 0.294 |
| Bitragion chin arc | 0.368 | 0.962 | **0.034** |
| Bitragion coronal arc | 0.545 | 1.042 | 0.087 |
| Bitragion supraorbital arc | 0.590 | 1.567 | 0.875 |
| Bitragion subnasal arc | 0.689 | 2.522 | 0.405 |
| Face width | 1.018 | 2.297 | **0.041** |
| Head width | 0.480 | 1.468 | 0.539 |
| Head length | 0.509 | 1.281 | 0.364 |
| Inter-pupillary distance | 0.176 | 5.245 | 0.964 |
| Lip length | 0.185 | 1.175 | 0.106 |
| Maximum frontal breadth | 0.534 | 1.144 | 0.205 |
| Minimum frontal breadth | 0.636 | 1.423 | 0.809 |
| Face length | 0.205 | 1.219 | 0.128 |

| | | | |
|---|---|---|---|
| Nasal root breadth | 0.023 | 1.322 | 0.091 |
| Nose breadth | 0.753 | 1.132 | 0.444 |
| Nose protrusion | 0.006 | 0.195 | **0.000** |
| Nose length | 0.267 | 5.797 | 0.781 |
| Head circumference | 1.092 | 2.405 | **0.017** |
| Neck circumference | 0.477 | 0.757 | **0.000** |

The table shows five significant parameters which can be relied upon to differentiate between males and females. The most significant parameter is nose protrusion and neck circumference followed by head circumference, bi-tragion chin arc and the least one is face width measurement.

## DISCUSSION

Racial differences affect even in small localities so that, updated formulas are urge for forensic science development [13].

This study describes 19 linear facial measurements in upper Egypt young volunteers. It contains the distinctive measurements that distinguish Egyptians from other people. The study also includes the facial measurements of young Nubian volunteers and the differences between the Nubian and NNUE.

These measurements are affected by the environmental factors of the area as hot temperature, dryness of the air and are also affected by the food habits of the upper Egypt population.

The gender plays a vital role in measurements either in Nubian or in NNUE. As general knowledge, the males have larger parameters [14].

Racial factor also plays an important role that in contribution with the natural gender differences that makes males parameters larger than females' . for example in the current study, the natural differences between males and females are significant in 16 out of 19 parameters in NNUE while the same parameters show only 9 differences between Nubian males and females.

The racial factor affects different nations in the same gender. For example, there are 10 significant differences among males of Nubians and NNUE and 6 significant differences among females.

Climatic adaptation and geology of different areas also affects the facial features to coup with these conditions as latitude, solar radiation, vapor pressure and temperature [15].

Bergmann's rule explained the effect of climate on body measurements including head. The type of food consumed wither hard or so, food affects also muscles of mastication especially the masseter muscle and the shape of mandible also is affected by the type of diet [16].

The head parameters in current study resemble those of the middle east nations and are different from those of Europeans. Also the measurements of Nubians in present study are close to both NNUEs as they live in same climatic conditions and consumes the same type of food and also are close to negros as the racial affection is clear in some parameters .

Climatic conditions affect not only head parameters, but also nasal ones as the nose is greatly affected by humidity and temperature. Groups from cold areas tend to have taller noses to warm the air entering the nose along his length while those from hot and humid climates as in the negros that live around the equator tend to have short wide noses to cool the hot inspired air as the air rolls in circles on entering wide nose before enter the lower respiratory track [17].

The nose shapes are classified into three major types, leptorrhine, mesorrhine and platyrrhine. The Egyptian type of nose is in the borderline between mesorrhine and leptorrhine [18].

In the current study, nasal dimensions show racial differences between Nubians and NNUEs as the Nubians tend to be wider and shorter than NNUEs as they have negro racial affections while the NNUEs are close to those of middle east populations.

Mandibular measurements are affected by race and gender. The Nubian race tends to have smaller bi-gonial breadth than NNUEs and the Nubian males and females don't show significant difference in this parameter while in NNUEs there is significant difference between males and females in this parameter.

## CONCLUSION:

This study revealed a significant difference between Nubians and NNUE in general, Nubian males and NNUE males, Nubian and NNUE females, Nubian males and Nubian females and also between NNUE males and females.

The results indicate also that in NNUE, the measurements are close to those of the middle east populations and different from European population while in Nubian samples, they are also close to a great extent with the measurements of NNUE volunteers and also with Negro race in some measurements as the nasal dimensions, head circumference, head and face length and lip length.

## REFERENCES


1. **Boer H., Obertová Z., Cunha E., Adalian P., Baccino E., Fracasso T., Kranioti E., Lefévre P., Lynnerup N. and Petaros A., (2020).** "Strengthening the role of forensic anthropology in personal identification: Position statement by the Board of the Forensic Anthropology Society of Europe (FASE)". Forensic science international 315. p.110456.
2. **Petaros A. Caplova Z. Verna E. Adalian P. Baccino E. De Boer H. Cunha E. Ekizoglu O. Ferreira M. and Fracasso T., (2021).** "The Forensic Anthropology Society of Europe (FASE) map of identified osteological collections". Forensic science international. 328. p.110995.
3. **Georgopoulos M. Panagakis Y. and Pantic M., (2018).** "Modeling of facial aging and kinship: A survey". Image and Vision Computing. 80. p.58-79.
4. **Kuang Q., (2021).** "Face image feature extraction based on deep learning algorithm". In Journal of Physics. 1852(3). p.032040.
5. **Ajala O. and Viriri S., (2021).** "Deep learning approach for facial age classification: a survey of the state-of-the-art". Artificial Intelligence Re-view. 54(1). p.179-213.
6. **Meral O. Meydan R. Toklu B. Kaya A. Karadayi B. & Acar T., (2022).** "Estimation of sex from computed tomography images of skull measurements in an adult Turkish population". Acta Radiologica.63(11). p.1513-1521.
7. **Elsamny T., Rabie A., Abdelhamid A. and Sobhi E., (2018).** "Anthropometric analysis of the external nose of the Egyptian males". Aesthetic plastic surgery. 42(5). p.1343-1356.
8. **Ozdemir F. and Uzun A., (2015).** "Anthropometric analysis of the nose in young Turkish men and women". Journal of Cranio-Maxillofacial Surgery. 43(7). p.1244-1247.
9. **Moustafa S., (2014).** "Sexual dimorphism of selected mandibular anthro-pometric parameters in Saudi population sample: application in forensic identification". Ain Shams Journal of Forensic Medicine and Clinical Toxicology. 23(2).p.43-49.

10. **Akhlaghi M., Khalighi Z., Vasigh S. and Yousefinejad V., (2014).** "Sex determination using mandibular anthropometric parameters in subadult Iranian samples". Journal of forensic and legal medicine. 22. p.150-153.
11. **Deng M. Bai R. Dong H. Mu J. Lin W. and Zhou Y., (2017).** "Sexual determination of the mandible breadth in a central Chinese population sample: a three-dimensional analysis". Australian Journal of Forensic Sciences. 49(3). p.332-343.
12. **Yildirim Y., Sahbaz I., Kar T., Kagan G., Taner M., Armagan I. and Cakici B., (2015).** "Evaluation of interpupillary distance in the Turkish population". Clinical Ophthalmology (Auckland, NZ). 9. p.1413.
13. **Cappella A. Gibelli D. Vitale A. Zago M. Dolci C. Sforza C. & Cattaneo C., (2020).** "Preliminary study on sexual dimorphism of metric traits of cranium and mandible in a modern Italian skeletal population and review of population literature". Legal Medicine.44.p.101695.
14. **Ahmed A. and Taha S., (2016).** "Cephalo-facial analysis to estimate stature in a Sudanese population". Legal medicine. (20). p.80-86.
15. **Pan L. Wei D. & Wu X. (2014).** "Latitudinal and climatic distributions of 3D craniofacial features among Holocene populations". Science China Earth Sciences. 57. P.1692-1700.
16. **Nowaczewska W. Dąbrowski P. & Kuźmiński Ł. (2011).** "Morphological adaptation to climate in modern Homo sapiens crania: the importance of basicranial breadth". Collegium antropologicum. 35(3). P.625-636.
17. **Stansfield E. Mitteroecker P. Vasilyev S. Vasilyev S. & Butaric L., (2021).** "Respiratory adaptation to climate in modern humans and upper palaeolithic individuals from Sungir and Mladeč". Scientific Reports.11(1).7997.
18. **Hegazy A., (2014).** "Anthropometric study of nasal index of Egyptians". Int J Anat Res. 2(4).p.761-67.
19. (https://www.dreamstime.com/stock-illustration-blank-white-female-head-front-view-human-image41041470)
20. (https://www.dreamstime.com/royalty-free-stock-image-model-blank-white-male-head-side-view-image30057896 )
21. (https://www.google.com/search?q=sliding+caliper&sca_esv=590226030&tbm=isch&source=lnms&sa=X&ved=2ahUKEwjzuszQu4qDAxUlU6QEHUVaBYkQ_AUoAXoECAQQAw&cshid=1702403628287473&biw=1366&bih=619&dpr=1#imgrc=MBFoADqM7R-OgM)
22. (https://www.google.com/search?q=measuring+tape&sca_esv=590226030&tbm=isch&source=lnms&sa=X&ved=2ahUKEwiEnY-dvIqDAxVFQ6QEHYQvAlcQ_AUoAXoECAIQAw&biw=1366&bih=619&dpr=1#imgrc=osScgYRsRwH8KM)
23. (https://www.google.com/search?q=manual+pupillometer&sca_esv=591396670&tbm=isch&source=lnms&sa=X&ved=2ahUKEwiLmMbo6pKDAxV1XfEDHa5zBOUQ_AUoAXoECAIQAw&biw=1366&bih=607&dpr=1#imgrc=6tq9D1wobxNl7M )