Systematic review on heritability of craniofacial characteristics between the generations of the family

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Abstract

Face recognition is one of the most required problems in applied Biometrics. It has been likely to improve feasible techniques for physical world applications after ages of study in this particular area. This study describing findings from various research papers of the genetic of the human face and the aim of this review were to describe the heritability of the facial dimensions and facial features between the generations of the family to better understand the genetic architecture of facial dimensions and facial features also. The study result revealed that the maximum correlation was found between father-son and mother-daughter, while the smallest relationship was observed for numerous of the factors in other-sex couples. The girl demonstrated the same heritage from both parents. Overall face size, lip prominence, and chin demonstrated the strongest heritability, but nose and lip shape indicated the least relationship. The outcome of this analysis shows that there is a relatively effective genetic control in the transfer of facial soft tissue traits. In common, consistent data illustrating soft-tissue facial summaries can be attained from pictures of subjects in correct head poses. Additionally large sample size studies should perform using the parameters from this study that showed the highest correlation.

Keywords: Craniofacial feature, Heredity, facial characteristics

1 INTRODUCTION

Face recognition is one of the most required problems in applied Biometrics. It has been likely to improve feasible techniques for physical world applications after ages of study in this particular area.

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Inheritance is the transferring of traits from one generation to another generation, also called **heredity**. The human face is a complex characteristic demonstrating a powerful hereditary factor (15), as per demonstrated by significant facial resemblance among monozygotic (identical) twins, families with the perfect facial similarities, geographical population (14) as well as the genders (14), and lastly the distinguishing facial characteristics related with individual hereditary conditions (10). This recommended that inter-solitary dissimilarity in cranio-facial configuration is mostly decided by genetic deviation, in connection with various environmental changes. Research on cranio-facial inheritability offers awareness into the respective association of heredity versus environmental effects on anthroposcopic variables of cranio-facial factors. These observations focus resemblances as well as variances in conformations of heredity, resulting from variances in the study population (age of valuation, sample size, sex, ethnicity), in the techniques (2D or 3D), in the technique facial character is measured and lastly in the statistical techniques generated.

Numerous studies have been performed to identify the quantity of heritability of the skeletal constituents but the heritability of soft-tissue arrangement are hardly predictable about which is associated by every single person once the child step into the world. Facial appearances is influenced by both genetic and environmental aspects which act together in multidimensional resource to express the form and function of the cranio-facial complex. The appearance and changes during the time and ageing in the face is documented by use of **Cephalometry and photography in orthodontics**. Chang et al., 1998 tries to highlight the facial similarities between the parent and their young ones as a portion of orthodontic study (2). The procedure taken in to measure the resemblance used in many ratios between the lengths between the facial traits. It is found that the facial expression are also inherited (17).

Here this study describing findings from various research papers of the genetic of the human face and the aim of this review were to describe the heritability of the facial dimensions and facial features between the generations of the family to better understand the genetic architecture of facial dimensions and facial features also.

1.1 OBJECTIVES

This paper aimed to review the literature and synthesis available data that focuses the following questions: -

1. To examine the growth of facial dimensions as a heritable trait or to determine the genetic predisposition to facial dimensions in the family.

2. To examine the growth of Facial Features be defined as a heritable feature or to determine the inherited tendency to facial dimensions in the family.

2 MATERIAL AND METHODS

2.1 Search Strategy

Literature search strategy for the papers related to heritability of facial features; genetics of human face was searched on Google research scholar, research gate, Clarivate Analytics Web of science, NCBI, Science Direct, PUBMED, Scientific World journal and the terms "Heritability" AND "facial Features" (OR Facial dimensions" OR Family)" are used by International Journal of Forensic Sciences from 1970 to 2019. The search has been supplemented with relevant references retrieved from the retrieved list of reference papers found in the reference directories at the article evaluation phase.

2.2 Inclusion and Exclusion Criteria

Findings were taken as of the titles and summaries utilizing the subsequent inclusion standards:

1. Initial findings from the families give statistics about familial aggregation.
2. Initial epidemiological analyses that give indication about heritability involving ethnic variations.
3. Significant systematic reviews that give evidence about inheritances for facial features.
4. Relevant systematic reviews that provide information about genetics or heredity for facial dimensions.

Studies were eliminated if they were general chronicle reviews or opinion pieces, about non-human or disease or described pathologies other than facial features and facial dimensions.

2.3 Study Selection & Data Extraction

Data were extracted from the retrieved complete details of hypothetically appropriate studies. The study design, facial traits and kind of the conclusions were collated and coded red for omission, green for inclusion and amber to denote vagueness. All findings that got the insertion (inclusion) criteria were included irrespective of worth.

2.4 Data Synthesis

A narrative production was performed to discover the study problems about the heritability and inheritance association described for the Facial dimensions and features. The study date, first author, design of the study, no. of subjects , facial dimensions, and features in the generations of the family and direct references from analysis or inferences are tabulated.

3 RESULTS

3.1 Study selection and data extraction

The database identified 36247 unique studies, of which 21332 were duplicates. Of the remaining 14915, 40 met the initial inclusion criteria. Most studies were excluded at the abstract or primary manuscript review stage, but 11 manuscripts were excluded at the data extraction stage because there were no relevant primary data identified about heritability of facial dimensions and features. Comprehensive screening of the full text of the remaining 29 papers meeting inclusion criteria and were ultimately integrated in this narrative fusion (see Figure 1).

3.2 Risk of Bias

literature that was relevant to fulfill the objectives about the heritable facial dimension and components in the family. Many of the studies provide some indirect evidence only, given that the author's objectives were to describe the heritability of the facial traits from parent to offsprings.

Year of Publication	First Author	Number of subjects	Gender	Author conclusion extracted from manuscript (original language in parentheses)	Facial Features
1970	Hunter WS	31	Male Female	Fathers and offspring were demonstrating the greatest statistical connections between each other. They were reliably greater within the even dimensions in parents and offspring. The mandibular dimension shows strong connection between fathers and their offspring. The mothers and offspring were showing lower statistical relation than those between fathers and offspring.	Mandibular dimension
1975	C.Susanne	125	Male Female	The indication from the parent-child and mid-parent-child relationship factors that the level of genetic examination differs suggestively from one dimension to alternative, being highest in the longitudinal physique dimensions, minimum in the boundaries concerning soft tissues and in dimensions of the nose and mouth.	Nose, Mouth
1980	E.F. Harris	50	Male Female	The genetic support to occlusal deviation given or demonstrated by a large age- consistent series of relatives is low.	malocclusion

1980	Saunders SR	147	Male Female	The first-degree connections which are consistent with a polygenic hypothesis of inheritance reveals important level of considerable relationship. These records provide no indication of improved consequences of autosomal supremacy and sex-association. The use of numerous dimensions from each parents provides the finest conclusions while one is endeavoring to calculate a child's craniofacial proportions as anticipated.	Craniofacial
1988	Suzuki A	150	Male Female	The children's craniofacial shape correlated strongly including their parents. 2. The hereditary impacts of establishing the cranio-facial shape of progeny from the father were akin to those by the mother, though, girls were further persuaded by parents than were sons. 3. The proportions of multi-regression functions ranged from 3.7 to 34.0 percent. These values are too low to predict the growth of a child. 4. The calculated heritability on craniofacial form were from 0.286 to 0.962, with the majority being more than 0.600. 5. The coefficients of correlation between the children and their parents increased with growth, regardless of their orthodontic treatment	
1991	A. Suzuki	500	Male Female	This analysis established the belief of “similar parent” and “dissimilar parent” as an alternative of the father and mother similarly.	Craniofacial
1998	Chang CP	100	Male Female	1. The characteristic that became most importantly correlated among parents and offspring is the nose. 2. The comparative positions of other elements to the eyes than for specific elements of the facial similarities was significant among parents and offspring. 3. The correlations among one parent and offspring were lower than between 'mid-parents' (the mean value of both parents) and offspring. 4. The relationships among parents and offspring for range were greater or significant than those for form. 5. The resemblances among father and offspring were lesser than those between mother and offspring.	Nose, Eyes. Lips, nose
2001	Carels. C	79	Male Female	1. The vertical variable of the genetic determination is significantly higher compare to the horizontal variables. 2. Each variable preferred appear to be hereditary by additional genetic factor, excluding for the length of mandible body, which was defined by leading alleles as far as the inherited factor is involved. 3. Gender variations in inherited purpose were discovered for the frontal face height, indicating a considerably greater inherited factor for boys (91%) than for girls (68%).	

2005	B.Johannsdottir	363	Male Female	Hereditary deviations can be proven for complex polygenetic multifactorial characteristics. Cephalometric information can help estimates and evaluation of parental records could have projecting values for children.	
2006	E Ann Carson	298	Male Female	1. Greatest joint breadth sizes in this analysis appear minimal heritability approximations, whereas cranial length and height sizes have heritability standards varying in the middle of 0.102 - 0.729. 2. The highly prominent class of dimensions is that of the orbital /midface region, including several measurements showing heritability below 0.30. 3. Heritability calculated on one populace have to now no longer be carried out to others	
2007	Al-Gunaid T	50	Male	The soft-tissue facial profiles of white Yemenis and Americans are different in certain respects; these racial differences must be considered during diagnosis and treatment planning.	Face, nose, lips chin
2008	Toma A.M	350	Male Female	1. Women have a tendency to have additional prominent eyes and cheeks in connection to men with a highest variance of 2.4 mm. 2. Men have a tendency to have additional prominent noses and mouths with a highest variance of 2.7 mm. 3. Around 31% of the facial fit precisely (no discrepancy), in the forehead and chin areas of the face.	Nose, Mouth, Chin, eyes, cheeks
2008	Charlie D. Frowd	24	Male Female	The face bred is still being used by the people to identified from the system. The random faces shows better significance during the performance. $t(60) = 2.77$, $p = 0.007$.	
2010	Tina D.	24	Male Female	3 categories of dimensions revealed greater standards in the father-offspring than the mother-offspring classes, with the father-daughter combinations additionally considerable than the father-son classes.	
2010	Jelenkovic A.	474	Male Female	the existence of a significant genetic component determining the four craniofacial synthetic traits, and common genetic and environmental effects shared by the two face-related phenotypes and by the head-related ones.	
2012	Sachan A.	60	Male Female	1. Soft-muscle dimensions demonstrated that boys had more soft-muscle facial angle (92.10°) than girls (89.92°). Also, they had more nose prominence (18.10 mm) than women (16.44 mm). 2. Basic upper lip thickness was higher in men (16.60 mm) compared to women (14.24 mm), while H-angle was higher in women (16.68°) as compared to men (14.30°). 3. In the lower face area, inferior sulcus to the H line distance was more in males (7.30 mm) than females (4.80 mm). Males	

				had larger soft-muscle chin depth (14.10 mm) than females (12.84 mm).	
2012	Negi N.	60	Male Female	1. The nose prominence, superior sulcus depth, soft-tissue sub-nasale to H-line, basic upper lip depth, max incisor to upper lip, H-angle, lower lip to H-line and soft tissue chin depth shows statistically significant differences. 2. Statistically significant variations were obtained for essential superior lip depth, max incisor to superior lip and H-angle in comparison of the gender.	
2012	Ikenna IsiekweG.	100	Male Female	In 8 of the variable studies between the men and women of the Nigerian population shows statistical significant differences in which men having greater prominent upper and lower lips than the women. Soft tissue facial angle, nose prominence and soft tissue chin depth are the variables, which did not differ by gender.	
2013	Lahoti S K	140	Male Female	The evidence of significant genetic contribution was there for linear and proportional parameters. Boys demonstrated greater heritability to their mothers than to their fathers while daughter showed heritability from both the parents. Thus, the soft tissue form of offspring can be predicted from parental data and the information from the siblings can also be used.	
2013	Weinberg S.M.	21	Male Female	Three principal components displayed evidence of moderate to high heritability and were associated with variation in the breadth of orbital and nasal structures, upper lip height and projection, and the vertical and forward projection of the root of the nose due to variation in the position of nasion.	
2016	Jelena D.	229	Male Female	1. Hereditary aspects can describe additionally 70% of the phenotypical facial difference in facial dimension, nose (width, prominence, and height), lips prominence and inter-ocular distance. 2. A little characteristics have demonstrated potential dominant genetic influence: the prominence and height of the nose, the lower lip prominence in relative to the jaw and upper lip philtrum length.	
2018	Imami M.M.	100	Male Female	Nose eminence, elementary superior lip width, superior lip depth and straining, lower sulcus to H-line and soft-tissue chin depth in Hold away analysis and maxillary prognathism, inferior plumb height-depth proportion, mento-labial sulcus deepness and upright lip-chin proportion in Legan and Burstone study were superior in men. Kurds have considerably various soft-tissue cephalometric standards associated to Caucasian standards.	
2018	Kim E.	13	Male Female	The structure of facial skeletal composition and position of the occlusal level contained by skeletal outline was further manipulated by inherited considerations than conservation aspects.	

2018	Mathews H S.	894	Male Female	By evaluating regular dimensions, or single standard faces differences in head shape among groups are highly regularly evaluated. Though, knowing how these variations appear and adjustment can require perceptions into the fundamental natural and inherited processes.	
2019	Nikola M.	52	Male Female	This design signifies the initial photogrammetric evaluation of facial soft-tissue attributes of teenagers and adults in the Serbian people. The statistics recommend that there are much more than comparisons among the facial soft-tissue angles of dads and their boy children. Additionally, moms have a tendency to have statistically inconsequential variations in angle dimensions, associated to together boy and girl offspring.	
2019	Haiz Taha M.	70	Male Female	The males showed more prominent upper and lower lips, decreased prominence of nasal tip and increased soft tissue chin thickness as compared to females while females showed less prominent upper and lower lips, increased prominence of nasal tip and decreased soft tissue chin thickness as compared to males. Moreover, significant differences were found in various angular parameters among males and females.	
2019	Rakhshan V	130	Male Female	Age had no meaningful impact (all P values > 0.01). Sexual dimorphism occurred in conditions of several factors. Associated to study values, superior lip to E-plane, nose prominence, superior lip depth, nasomental angle, Z angle, interlabial distance, subnasale perp to chin, sub-nasale-stomion:stomion-menton, subnasale-lower lip:lower lip-menton, interlabial gap, and plumb lip-chin proportion were slighter in Iranians. Greater sulcus deepness, skeletal outline convexness, superior lip strain, superior lip arc, H-angle, soft tissue chin depth, naso-facial angle, sub-nasale perp to superior lip, sub-nasale perp to inferior lip, maxillary prognathism, inferior face throat angle, superior lip protrusion, inferior lip protrusion, mento-labial sulcus, and inferior plumb height-depth ratio were superior in Iranians associated to the standard.	
2021	Tina D. AlKhudhairi	24 families	Male Female	er facial-height proportion had superior similarity to parents concerning comparative dimensions. In cooperation the association factors and the hereditary standards of these attributes were greater in the father-offspring than the mother-offspring combinations. The daughters' cephalometric craniofacial attributes were additional concerned by the parents than were those of the boy child.	

4 DISCUSSION

This is the first systematic review to discover the statutory heritability of the facial feature and dimensions in the family. This search synthesized information from 35 available findings about heritability of the facial features and dimension in the family.

From these, 29 papers have been identified pertaining to heritability of the facial features and facial dimensions.

This study summarized the available evidence concerning the heritability of facial features and dimensions.

This study presents an innovative method to regulate facial inheritance and co-inheritance in the generations of the family, by merging the co-inheritance of adjacent quasi-standards, different physical characteristics with specific inheritance were created grounded on the genetic methods of heritability. Add-on to the evaluation of co-inheritance, a subsequent feature of this design is the multi-variate examination of facial structure at numerous stages of association.

The most noticeable feature in the one of the studies was the significantly higher correlation among fathers and children than among mothers and children. The correlations among the father-offspring, concept quite fine and maintain the theory that facial measurements have a considerable genetic factor however the mother-offspring connections do not. (1)

It was seen that the parent-offspring and mid-parent-offspring relationship factors shows the level of heri- table determination differs significantly from one dimension to other, actuality extreme in the longitudinal physique proportions, minimum in the perimeters concerning soft-tissues and in dimensions of mouth and nose. There was extreme degree of considerable relationships among first-level families which are corresponding along with a inheritance by polygenic hypothesis.

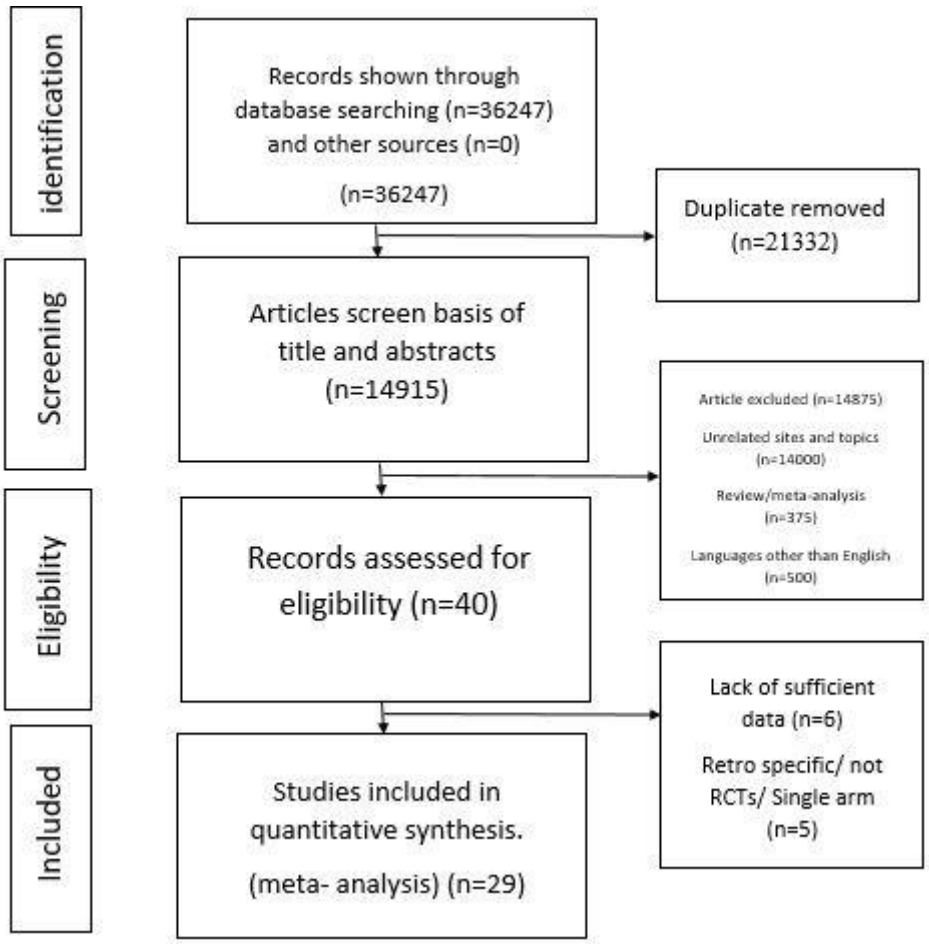

FIGURE 1

Flow chart which summarizes Study selection & data extraction(The identification and screening of studies for inclusion in the narrative synthesis is illustrated in this PRISMA flow diagram)

The application of various dimensions from together parents provides the greatest outcomes while one is trying to calculate a offspring's craniofacial dimensions.

The results of the heritability also shown that: The points that was most suggestively associated among parents and offspring was the nose; The relationships among parents and offspring were closer for the comparative positions of additional features to the eyes than for distinct features of the face. The relationships among 'midparents' (the mean value of both parents) and offspring were advanced than those among one parent and children; The associations among parents and children for magnitude were advanced than those for shape; The resemblances among mothers and children were significant than those among males and offspring. (2) Also, the hereditary reason is considerably greater for erect (72%) than for parallel (61%) variables. As much as the hereditary factor is related, the whole variables designated appear to be hereditary by additional genetic factor, apart from measurement of mandibular body, which was defined by major alleles. Gender variations in inherited purpose were initiate for the frontal face altitude, giving a considerably elevated hereditary factor for men (91%) than for women (68%).

The maximum relationship was commenced among the boy - father and daughter- mother although least relationship was noticed for several of the factors among the additional gender sets. Girl child demonstrated equivalent legacy equally from mother and father. The overall facial elevation, lip and chin prominence shown the greater inheritance but the lip as well as nose type revealed the smallest relationship. The elements of parallel and perpendicular dimensions, the greatest relationship was found among son and his mother.(7) In common, comparable forms of facial characteristics were genetic from the young offspring to their father, containing the universal face, upper facial components the nose, forehead, nasion, orbital region. Remarkably, boy child demonstrated greater inheritance to their dads than girl child did at the age of 15.(9) Lower facial elevation proportion had superior similarity to par- ents with respect to comparative dimensions. The relationship factors and the genetic standards of these traits were greater in the male-offspring than the female-offspring combinations. The girl's cephalometric cranio-facial features were further influenced by the mother-father than were those of the boys (10). Girls had additional variables that touched the degree of sig- nificant than did boys. Girl child indicated related inheritance to both mother-father at each age stages, however further variables were greatly considerably significant ($P <$ or $= .001$) in the girl child-father classes. Boys have better inheritance to mothers in each cases. The vari- ables presented the highest inheritance were individuals demonstrating the site of the shorter jaw, the frontal and rear face elevations, and the cranial base measurements. Inheritance was remarkably little for the dental consonant variables. (3) The univariate analysis of the skeletal

heritability approximation appears to put together into individual areas of the skull, according to their comparative principles. The extremely protruding set of dimensions is for the orbital / midfacial area, with number of ways revealing inheritance not more than 0.30. (4) Yemeni people demonstrated considerable deviations with regard to prognathism of mandible, shorter face-throat angle, naso-labial angle, mento-labial sulcus depth, and inter-labial difference, once matched with the Legan-Burstone standards for Caucasoid Americans. Maximum standards of both Yemeni groupings were usually with the limit of the standards described by Holdaway, excluding 3 variables: convexity of skeletal profile, basic superior-lip depth, and H-angle, which were every considerably greater than those of Holdaway.(5) Face producing method that creates photos of faces into a pattern and produces them with each other. The findings proposes that the method is effective in generating a likeness of the parents that other individuals can distinguish. (6) It was also found that 3 major components demonstrated indication of reasonable to high heritability and were linked with variation in the breadth of orbital and nasal structures, upper lip height and projection, and the vertical and forward projection of the base of the nose due to difference in the place of nasion.(7)

There were considerable variations in the standards of the nasal and cervico-mental angles, along with the angle of the complete facial convexness, among the set of males, on one side, and classes of boy/girl kids, on the other. Age had no considerable outcome. Sexual dimorphism occurred in periods of quantity of factors. Associated to study values, superior lip to E-plane, nose prominence, superior lip depth, naso-mental angle, Z angle, inter-labial distance, sub-nasale perp to chin, sub-nasale-stomion:stomion-menton, subnasale- lower lip:lower lip-menton, interlabial gap, and vertical lip-chin proportion were lesser in Irani- ans. Greater sulcus depth, skeletal profile convexness, upper lip tension, upper lip arc, H-angle, soft tissue chin thickness, nasofacial angle, subnasale perp to upper lip, subnasale perp to lower lip, maxillary prognathism, lower face throat angle, upper lip protrusion, lower lip lump, men- tolabial sulcus, and lower vertical height-depth proportion were superior in Iran population related to the standard. (8)

5 CONCLUSION

The study result revealed that the maximum correlation was found between father-son and mother-daughter, while the smallest relationship was observed for numerous of the factors in other-sex couples. The girl demonstrated the same heritage from both parents. Overall face size, lip prominence, and chin demonstrated the strongest heritability, but nose and lip shape indicated the least relationship. For the proportions of horizontal to vertical measurements, the greatest relationship among mother and child was detected. The outcome of this analysis shows that there is a relatively effective genetic control in the transfer of facial soft tissue traits. In common, consistent data illustrating soft-tissue facial summaries can be attained from pictures of subjects in correct head poses. Additionally, large sample size studies should perform using the parameters from this study that showed the highest correlation.

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