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Probability of Diabetes mellitus and Cardiometabolic Syndrome based on Facial Types

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Abstract- **With the advancement of technology it has been possible to detect diseases through non-invasive techniques. Previous studies showed us that diabetes mellitus and cardiometabolic syndrome are correlated disorders. Presence of one increased the possibility of existence of other. Efficient ways has been introduced to detect these disorders through facial image analysis using texture and color features. Furthermore, Human faces can be divided into three main categories based on the anatomical growth of their bones. Based on the knowledge the question arose that what could be the relation between facial types and these different categorical but linked disorders. Primary objective of this study is to analyze the facial types which have more probability of getting diabetes and cardiometabolic syndrome. Secondary objective includes the analysis of both genders i.e. male and female to detect which one of these genders are having more chances of these long lasting abnormalities. In the first step, data was acquired from four hospitals to make sure that it is accurate, both qualitatively and quantitatively. A few specifications were considered before capturing an image such as: frontal face, a distance of 3-4 feet between the camera and the subject, white background and neutral expressions. The age group of subjects was limited from of 30 to 80 years. The dataset consists of 198 participants including both male and female with equal number of subject in three groups namely diabetic, cardiometabolic and normal group. Facial index ratio was obtained after calculating the height and width of face using the anatomical landmarks described by researchers. After that each subject was classified into their respective group based on their facial ratio. Lastly, each group having different facial index ratio of project participant was analyzed statistically. Primary results showed that a large number of diabetic patients have wider and average faces also called mesofacial and brachifacial classes of face in medical terms. Further statistical analysis showed that there is a significant difference present between diabetic and normal group with P< 0.013 using CI of 95% and P<0.05. On the other hand, although large quantity of Cardiometabolic group belongs to mesofacial and brachifacial class but there was no concrete difference found between cardiometabolic and normal group using statistical analysis. Secondary results showed that in female there are more chances of these two disorders than male. The study concludes that rounder and average facial persons have more chances of diabetes mellitus and especially female are more affected by it. While there is no concrete result based showed that facial types have any relation with cardiometabolic syndrome.**

Index Terms-- **Facial Analysis; Facial Types; Diabetes Mellitus Detection; Cardiometabolic Syndrome Detection**.

I. INTRODUCTION

Cardiometabolic syndrome (CMS) or simply metabolic syndrome is a complex group of various abnormalities such as cardiovascular diseases (CVD), chronic kidney diseases (CKD), coronary heart diseases, stroke, inflammation and diabetes. Some of the vital factors which can induce CMS are obesity, hypertension, dyslipidemia and genetics [1-5] . Whereas diabetes mellitus is a metabolic disorder in which either the production of insulin is less than demand of the body or utilization of produced insulin cannot be used properly in the body [6-8] . Type-2 diabetes is the most common type and hypertensive patients have more chance to acquire it. Presently there is no proper cure for diabetes [2, 6, 9]. According to world health organization (WHO) estimation currently there are more than 171 million people suffering from diabetes and these numbers will increase to 366 million 2030 or 642 million by 2040 [7, 8]. Diabetes and cardiometabolic syndrome are correlated and any occurrence any of two will increase the risk factor for the other [1, 3-5]. There is a strong relation present between diabetes and edema, which is increment of bulk amount of body fluids in the tissue spaces between body cavities or cells. The change in the physical appearance is visible particularly on face[6]. A facial sign usually consists of color of skin, structure of bony zones, facial gesture and expressions and facial block analysis consists of two types of features such as texture and color[7, 8] . According to Chinese medicine cause, symptom, and origin of disease can be reflected through color changes.[8] Diabetes mellitus and cardiometabolic syndrome can be detected through non-invasive method using computer technology but there is no strong evidence present which showed that facial morphology is vital for cardiometabolic outcomes[2, 7, 10]. Facial asymmetry was observed in diabetic

patients such as dropping of brow ridge bugling of cheeks.[6] . Type-1 diabetic patients showed reduction of bone mineral density and decrement in skeletal mass which shows that changing in the craniofacial morphology due to reduction in muscle function.[11-14] Diabetic persons showed growth in zygomatic arch and those having hypertension have expansion in nasal region on the other hand, patients having both hypertension and diabetes Showed widening in the region of zygomatic arch and the jaw.[12]. Most common features of face can be detected through anthropometric measurements. Facial measurements include ratios, angles and landmarks detection. Due to advancement in computer technology various features of facial morphology can be detected with non-invasive, imaging technology techniques.[6, 15] some of the most common methods for analyzing faces of human are using imaging technology are face color blocks and facial texture features.[7, 8] Facial types can be divided into three basic types known as Dolicofacial, Mesofacial and Brachifacial. [16] For brachifacial skull is short in its anteroposterior where has dolicofacial have long cranial vault.[16] It was also observed that shape of diabetic patients was found to be rounder and less tapered.[15]. However there exist little or no knowledge in the facial analysis based on face types for determining the chances of diabetes or cardiometabolic syndrome. In this proposed study, Different types of faces have been examined using texture features of the face to determine the relation among facial type, diabetes and cardiometabolic syndrome.

II. METHODOLOGY

Entire project was divided into simple and concise steps for better understanding and less human error which could produce false results. Each Step from data acquisition to final results was done separately and critically examined before taking next step into consideration. Figure 1 show the steps involved in the whole project.

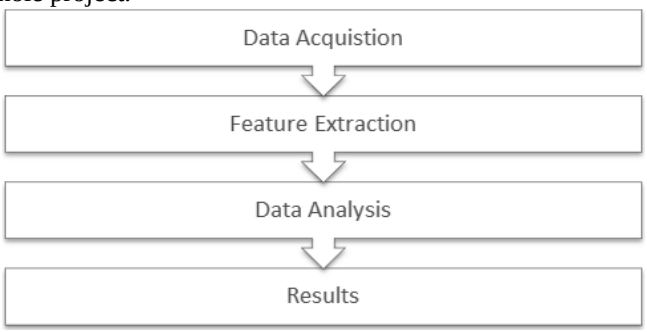

FIGURE 1. Graphical Methodology

A. Data Acquisition

Data was collected from four different hospitals due to two following reasons; one is the number of patients agreed to collect their facial images are low in numbers. Secondly, for quantitatively and qualitatively accuracy data from diverse regions were collected. Ethnic group of people belongs to Pakistan only. Both males and females were considered in this study. Three different groups were made for data acquisition namely Diabetic, cardiometabolic and normal group. Data was collected randomly without specifically targeting one group at a time. At the time of collection each participant was given a code which described the group in which a particular subject belongs. In last, each facial image was given code according to its group name while referring the code which was given during the time of acquisition.

A total 204 persons were included in this study and each group contains facial images of 68 participants. A written consent was signed from each participant who took part in this study. It was approved by each hospital's senior staff and home university ethical committee. Patient history related to diabetes and cardiometabolic syndrome was also noted down during data gathering. Table 1 provides an overview about the total subjects data collected from each hospital including patients from diabetic and cardiometabolic group. Table 2 showed the details about the data collected for each group from different hospitals. As the number participants were limited during data acquisition some of the males images have mustache and small beard, on the other hand females have accessions on their ears and nose. After careful consideration 6 images of male participants were discarded because they could produce variance in the results. Table 3 shows the specification and reason about rejection of images.

Table 1. Data Collection from four different Hospitals

Name of Hospitals	Number of Patients
Jinnah Postgraduate Medical Complex Karachi	111
Razia Diabetic Clinic Islamabad	26
Sidique Saddiq Memorial Trust Hospital Gujranwala	41
Major Shaheed Shaheed Sharif Hospital (THQ) Gujarat	26
Total Number of subjects	204

Table 2. Data Collection for each group from different hospitals

Name of Hospital	**Type of Subjects**		
	Cardiometabolic	Diabetic	Normal
Jinnah Postgraduate Medical Complex Karachi	25	42	44
Razia Diabetic Clinic Islamabad	Nil	26	Nil
Sidique Saddiq Memorial Trust Hospital Gujranwala	41	Nil	Nil
Major Shaheed Sharif Hospital (THQ) Gujarat	Nil	Nil	26

Table 3. Rejected Images

Number of subjects discarded	Reasons
6	Beard, Not in desired range of age

B. Data Specification

One of the vital parts of this study was data collection. The region of interest was face due to which some specific measure was taken into consideration before capturing images. View of face, background, facial expression and distance from camera were remained constant for the consistency in the obtaining data. These features of protocol allowed having good quality of dataset with some little variations. Table 4 showed the specifications of protocol used for acquiring data.

Table 4. Protocol used for acquiring data

Specification	Details
Background	White
View	Frontal Face
Expression	Neutral
Age group	30-80
Size of Image	2-3.4 MB
Pixels	5760 x 3840 & 4608 x 2592
Distance from Camera	3-4 feet
Camera and Lens	Cannon 24-105mm range

Before feature extraction the whole data was down-sampled and cropped to the size of 700X600 pixels due to limited processing power for batch processing. As the focal area was face in the image no part of face was cropped and images were having the same quality as can be seen in Figure 2. In addition to this brightness of each image from every group was maintained to one level for reducing the error which might be produced while capturing data from four different environments of hospitals.

FIGURE 2. Images of Subjects used in the study

C. Facial Index

The ratio between the morphological facial width to morphological facial height into hundred is called as facial index. It is also called as facial proportion. Mathematical expression for calculating facial index can be seen in (1).

$$Facial\ Index = \left(\frac{Morphological\ Facial\ Height}{Bizygomatic\ Width}\right) * 100 \qquad (1)$$

Facial height can be expressed as distance between anatomical points on face called Nathion (N) to Gathion (Gn) and facial width is defined as distance between byzygomatic widths staring from right zygion (Zyr) to left zygion (Zyl). Based on facial index facial types can be divided into three major types named as: Brachifacial, Mesofacial and Dolicofacial. Firstly, Brachifacial is the one in which width of the face is greater than the height of the face which can be calculated through facial index. Secondly, Mesofacial persons have on average height and width of the face. These faces are also called as normal or average faces. Lastly, Dolicofacial facial type is the one in which height of the face is greater than the width of the face. These faces are also referred as long or narrow faces. For categorizing any facial type a range of ratio was calculated by medical doctors [16]. Table 5, provides the details about the range of ratio for specifying the facial type.

Table 5. Ratio Range for each facial type

Facial Type	Ratio
Brachifacial	**X-84.9**
Mesofacial	**85.0-89.9**
Dolicofacial	**90.0-X**

D. Feature Extraction

The two vital parameters required for calculating the facial index were facial width and facial height. Facial type of each subject was predicted after calculating the facial index by using height and width as the features. Matlab image processing toolbox [17] was used for calculating the height and width of the face. Landmarks were pointed manually and straight line which is the distance between two landmarks for both height and width was drawn. This line provides the numerical value for width and height as shown in Figure 3. After calculation of these parameters facial index was calculated by using equation. 1. The whole process from width and height finding to calculation of index was repeated three times and an average values was taken for considering the facial type of the whole dataset.

FIGURE 3. Facial height and facial width calculation from anatomical landmarks

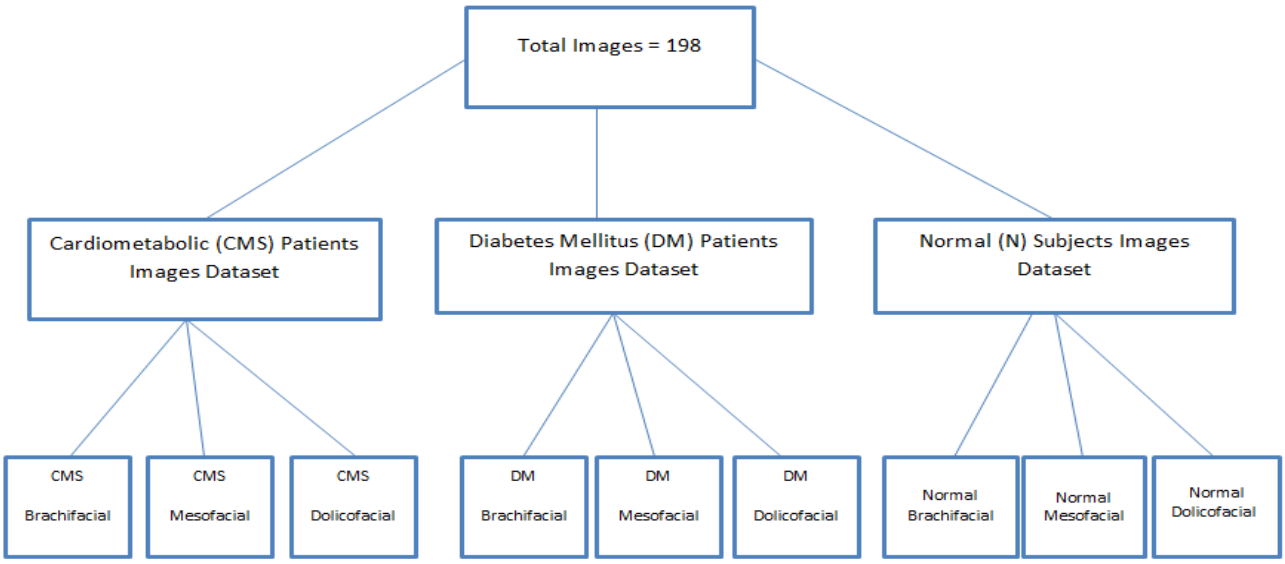

FIGURE 4. Division of Dataset based on Facial Type

III. RESULTS

This Dataset was separated based on the facial type by further dividing the groups into three relevant groups. Each group like cardiometabolic, diabetic and normal had had three of their own groups like Mesofacial, Brachifacial and Dolicofacial. A clear picture of this division can be seen in figure 4.

The finding showed that the diabetic group had most of the facial types which belonged to Brachifacial class whereas cardiometabolic group had on average an equal number of subjects laying in each class of facial types. On the other hand normal subjects have most the subjects who belonged to dolicofacial face type. Table 6, showed the details of subject belong to each class in all three groups

Table 6. Classification of subjects based on facial types in each group

Category	**Brachifacial**	**Mesofacial**	**Dolicofacial**
Cardiometabolic syndrome	26	16	24
Diabetic Patients	32	14	20
Normal Subjects	13	16	37

Gender based classification had also been done based on facial types. The finding showed that most of the female subjects in cardiometabolic group had brachifacial whereas most of the male had dolicofacial face type. In contrary to this diabetic group large number of male and female have brachifacial face type. For normal group the female had a large number of dolicofacial face type and male had a huge amount of faces contained in dolicofacial class. Table 7, and Table 8, provides the actual number of subjects both including male and female having facial type of particular class in the groups of cardiometabolic, normal and diabetes.

Table 7. Facial types of female belong to different groups

Gender : Female			
Category	Brachifacial	Mesofacial	Dolicofacial
CMS	18	10	3
DB	14	11	5
Normal	5	6	10

Table 8. Facial types of Male belong to different groups

Gender : Male			
Category	Brachifacial	Mesofacial	Dolicofacial
CMS	8	6	21
DB	18	3	15
Normal	5	12	28

The index ratio of all subjects in every group was averaged for determining the mean face each class hold. Figure 5, each class average faces in the form of bar graph. It was found out that the average of all subjects facial index in each of the three groups i.e. cardiometabolic, diabetic and normal belongs to mesofacial type which is within the range of 85.0 to 89.9 [16]

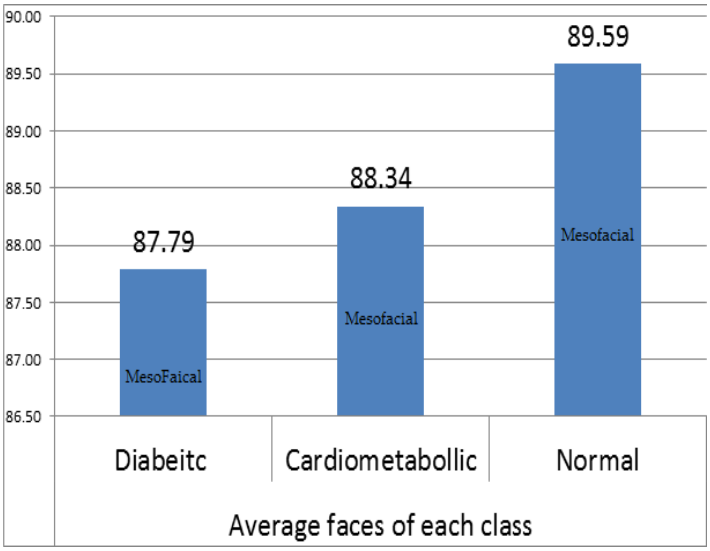

FIGURE 5. Average face of all subjects from each class 3.

Among all the groups, the diabetic group has (mean = 87.39, SD ± 7.87) whereas cardiometabolic group has (mean = 88.28, SD ± 8.50) and normal group has (mean = 90.64, SD ± 7.00). Data was found normal while checking with Shaprio-Wilk's W Test. Significance between groups had been checked using T-test independent sample at 95% CI with $P<0.05$. It was found out there is a significant difference present between diabetic group and normal group with $P<0.013$. On the other hand there was no significant difference present between cardiometabolic group and normal group.

IV. DISCUSSION

The results showed that almost 63.64 % of cardiometabolic patients are having facial types which are rounder and less tapered [15] including both brachifacial and mesofacial [16]. Both of these facial types are considered in the round face with wideness in the zygomatic arc. On the other hand only 36.36% of the patients in this class are dolicofacial [16] which belongs to the class of people having elongated face. For diabetic class patients 72.72% of the people belong to the mesofacial and brachifacial class combined which is validating the findings that diabetic persons have less tapered and rounder faces. Whereas only 27.28% of the data collected in this class have narrow faces. On the other hand in normal subject class only 43.9% have wider faces combing both mesofacial and brachifacial classes and 56.1% are dolicofacial persons. The classification based on gender provides different sort of results. In the category of female 90.32%, 83.33% and only 53.53% of cardiometabolic, diabetic and normal group subjects are having wider zygomatic arc [12] which are included in both brachifacial and mesofacial type. In contrary to this, male participants have only 40% of the cardiometabolic syndrome patients who belongs to brachifacial and mesofacial class. Whereas 58.3% are having rounder face and 52.38% of normal male participant have wider and average face. Based on these proportions the idea of diabetes for rounder persons is further strengthened while statistical analysis provides significant difference between normal group of facial index ratio of all three types of faces and the diabetic group facial index ratio. But for cardiometabolic syndrome there is contradiction present. The proportional data suggested that the are more chances present of cardiometabolic syndrome for those have wider and average facial types which is an alignment with the theory which states that facial signs are useful for predicting CMS [2]. On the other hand there is no statistical significant difference present between normal group and cardiometabolic group which is strengthen the results that [10] no strong evidence has been found on the basis of which one can surely say that facial morphology is vital for cardiometabolic syndrome. Further outcome based on gender showed us that there are more chances of diabetes and cardiometabolic syndrome in females while male data is not providing some convincing facts about the relation of facial type and the occurrence of diabetes and cardiometabolic syndrome. This study showed us that there are more chances of diabetes mellitus especially in female having the brachifacial and mesofacial type. For the relation of cardiometabolic syndrome it opens a new debate which provides the fact that whether there is a relation between any specific facial type and cardiometabolic syndrome.

There are some limitations present in the study. The first one is the participants are from same ethnic group, and therefore future studies have to include different ethnic groups for different findings. Secondly participants are from different cities and the lifestyles, culture and eating habits are variant that might affect the variation on the face. Lastly, the number of participants in terms of gender was not and equality in number of both participants can lead to different findings.

V. CONCLUSION

In recent years scientists had developed non-invasive techniques to detect various diseases which can be detected through facial analysis especially diabetes mellitus and cardiometabolic syndrome. In this study, we have analyzed the chances of

diabetes mellitus and cardiometabolic syndrome based on the types of the faces. Primary results showed us that those persons having brachifacial and mesofacial which means that their faces are rounder and wider in their form tend have more chances of diabetes mellitus while the risk of cardiometabolic syndrome to any specific facial type is still questionable as there was not significant results found related to this group. Secondary results showed that female are more prone to getting chances of diabetes and cardiometabolic syndrome as around 86.88% females both combining average and wider faces are having these disorders. For male participant there is no clear evidence and proportion on the basis of which any particular facial type considered as more prone to getting chances of these possible disorders.

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