Examination of Facial Shape Changes Associated with Cardiovascular Disease Using Geometric Morphometric

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ABSTRACT

Facial investigations using geometric morphometrics has been used in many studies to affirm that a particular disease can attribute to an individual's facial morphology. A landmark based geometric morphometric analysis was used in this study to asses if facial shape changes is associated with cardiovascular diseases (CVD) and if facial morphology of the CVD individuals differ from the normal ones. In the Municipality of Cantilan, Surigao del Sur, frontal face images taken from 32 cardiovascular disease patients and 32 normal individuals were examined using forty-one manually positioned landmarks. Result showed that facial morphology of the CVD group differ from non-CVD group. Procrustes ANOVA showed significant values for the individual symmetry and directional asymmetry. The analysis of structure by the Principal Components reveals particular variations and the scatter plot of the residual asymmetry shows distinct differences between CVD and non-CVD. Therefore, cardiovascular diseases contributes to facial shape changes and that development of facial morphology differ between CVD and non-CVD group.

INTRODUCTION

Human face is one of the structures in the body which is symmetrical; Symmetry implies that an organ or part of an organ is repeated in a different orientation or position and, therefore, that the spatial arrangement is strongly patterned and partly redundant (Klingenberg, Barluenga & Meyer, 2002). However asymmetrical character of a human face gives a unique asset for an individual as well. Human face is not just for recognition of a person; it also shows something in relation to the health of a person as shown in the studies of Mutsvangwa & Douglas (2006) and Solon, Demayo & Torres (2012). Cardiovascular disease (CVD) is a general term for disorders that affect mainly the heart and other vascular organs. Although the disease is more physiological, it is highly possible for it to have phenotypic manifestations (Solon, Torres & Demayo, 2012). The methods of geometric morphometrics combine the powerful and flexible tools of multivariate statistics with explicit consideration of spatial relations of parts and therefore make it possible to investigate morphological variation with direct reference to the anatomical context of the structure under study (e.g., Bookstein, 1991, 1996a; Dryden & Mardia, 1998; Meyer, Klingenberg and Barluenga, 2002). This study aims to investigate if there is variation in the face shapes of cardiovascular patients and the normal control using geometric morphometric analysis.

MATERIALS & METHODS

Research was conducted in Municipality of Cantilan, Surigao del Sur, Philippines. Cardiovascular patients was gathered through an inter-barangay survey with the assistance of barangay health workers. Copies of medical records were reviewed and confirmed that the patient was properly diagnosed by an appropriate medical doctor.

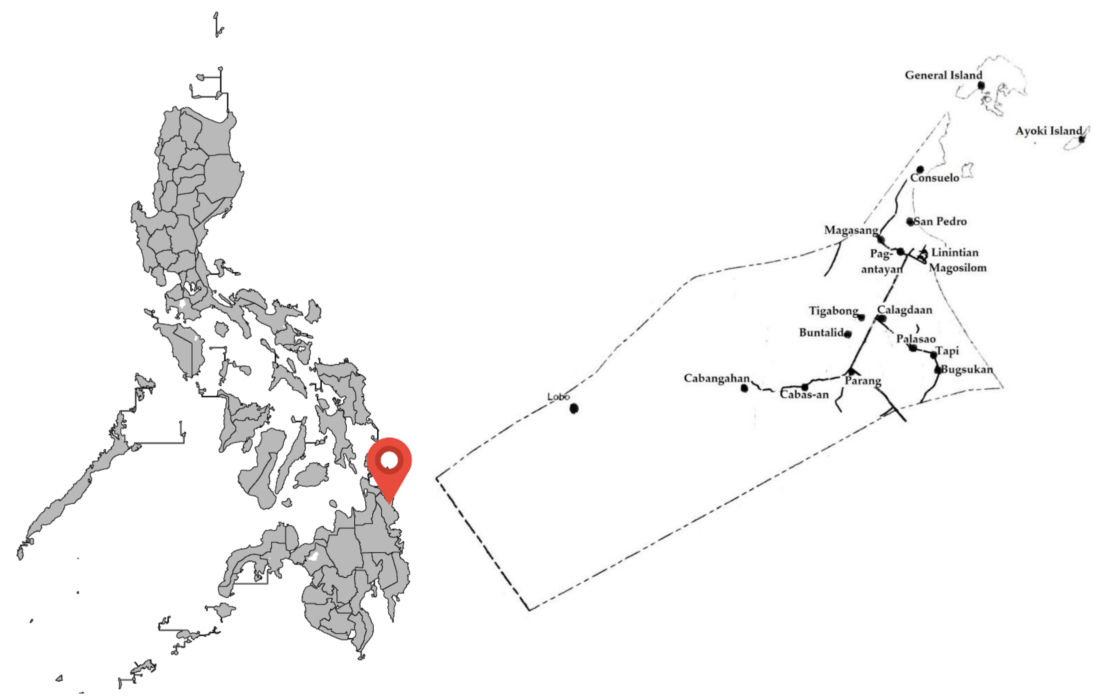
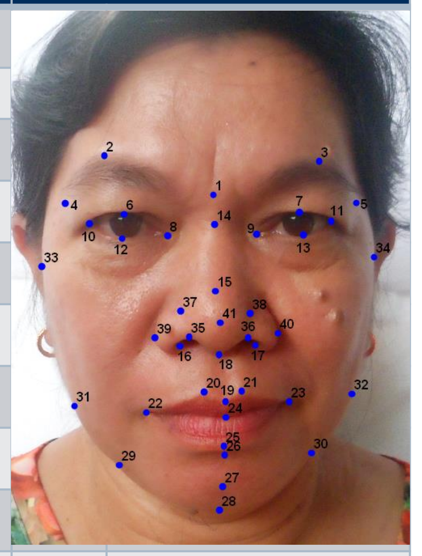


Figure 1. Topographic Map of the Philippines locating the Municipality of Cantilan, Surigao del Sur in Mindanao.

Digital images were taken with the assurance that their identity will remain confidential. Proper orientation of patient (eg. posture, hair pulled back and level of chin positioning). For uniformity, the distance between camera and patient was kept constant.

Table 1. Frontal Images Landmark positions

#	Landmark	#	Landmark	Anatomical Points	
1	Nasion	2,3	Superciliare		
4,5	Frontozygomaticus	6,7	Palpebrale superius		
8,9	Endocanthion	10,11	Exocanthion		
12,13	Palpebrale inferius	14	Sellion		
15	Pronasale	16,17	Lateral subalare		
18	Subnasale	19	Labiale superius		
20,21	Crista Philter	22, 23	Cheilion		
24	Stomion	25	Labiale inferius		
26	Sublabiale	27	Pogonion		
28	Gnathion	29,30	Tubercular	31,32	Gonion
33,34	Zygion	35,36	Supra subalare	37,38	Lateral pronasale
39,40	Superior alare	41	Infrapronasale		

Landmarked images were save as TPS file. Three replicates of the landmarked images were appended and then pooled into two groups. Analysis was carried out by the use of SAGE (Symmetry and Asymmetry in Geometric data).

RESULTS

There were a total of sixty-four (64) respondents, thirty-two (32) of whom are cardiovascular patients and thirty-two (32) persons comprise the control group who are free or undiagnosed of any illness and don't have health complaints. Sixty-four respondents are at the same age group which ranges from 40-75.

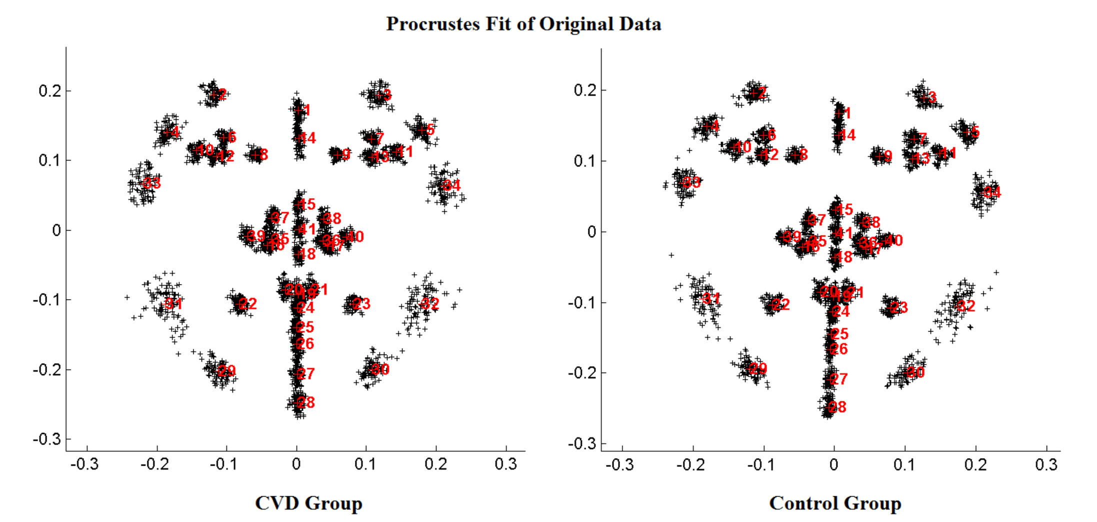


Figure 2. Procrustes fitted frontal face images for the control (non-CVD) group and CVD group.

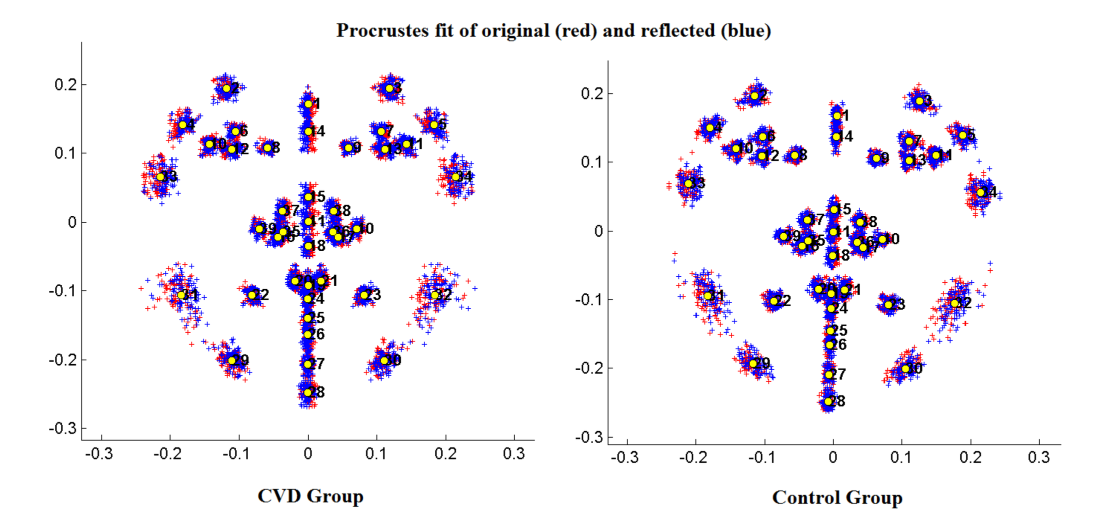


Figure 3. Procrustes fit of (a) original and (b) original (red) and reflected (blue) data of facial front images.

Table 2. Procrustes ANOVA in frontal face images of control (non-CVD) and CVD group.

Non-CVD (Control Group)					CVD Group				
	Individuals	Side	Interaction	ME		Individuals	Side	Interaction	ME
SS	0.0189	0.2835	0.0396	0.6657	SS	0.4051	0.411	0.0539	0.7252
df	39	1209	1209	4992	df	1209	39	1209	4992
MS	0.0005	0.0002	0	0.0001	MS	0.0003	0.0011	0	0.0001
F	14.7719	7.1492	0.2461	---	F	7.5747	23.6585	0.3069	---
P	0	0	1	---	P	0	0	1	---

ME – measurement error; SS – sum of squares; df – degrees of freedom; MS – mean squares; F statistic; P – level of significance.

Variation around this consensus by Procrustes ANOVA indicates that there were individual and directional asymmetry variation in symmetric shape however, fluctuating symmetry accounts for less of the total variation. Principal component analysis shows variation on the movement of particular landmarks (Fig. 4 & 5). Significant shape differences in the face of the two groups are supported by the distribution of the samples along the first two component axes. The negative region of component 1 was occupied by the CVD group while the positive region of component 1 was occupied by the non-CVD group (Fig. 6).

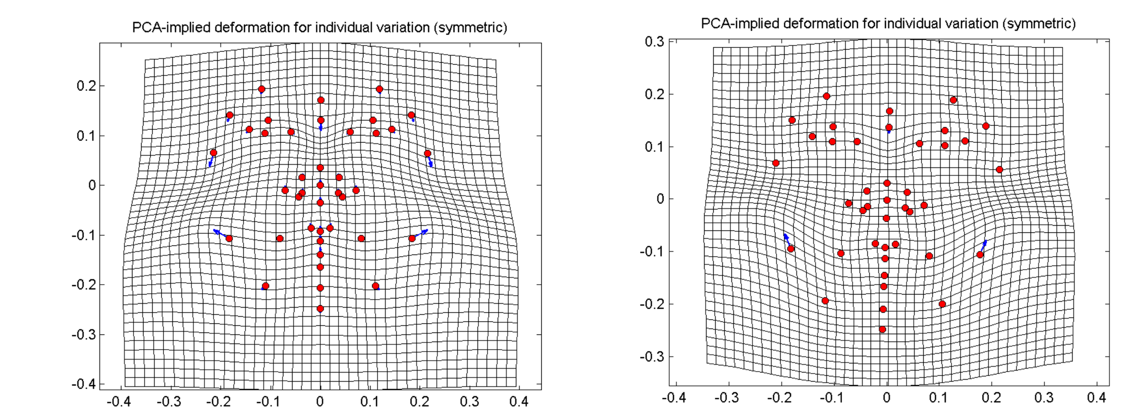


Figure 4. PCA-implied (PC1) deformation for individual variation (symmetry) of frontal images of non-CVD individuals (left) and CVD group (right).

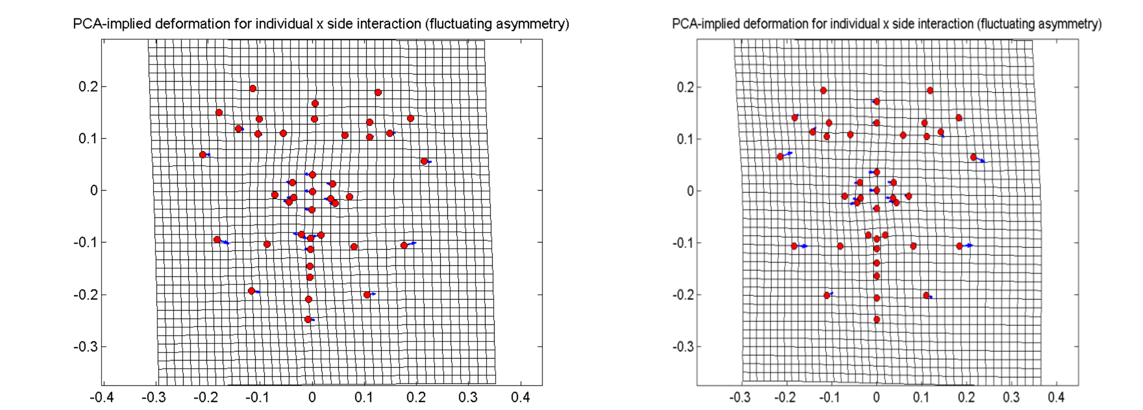


Figure 5. PCA-implied (PC1) deformation for individual X side interaction (fluctuating symmetry) of frontal images for non-CVD (left) and CVD (right).

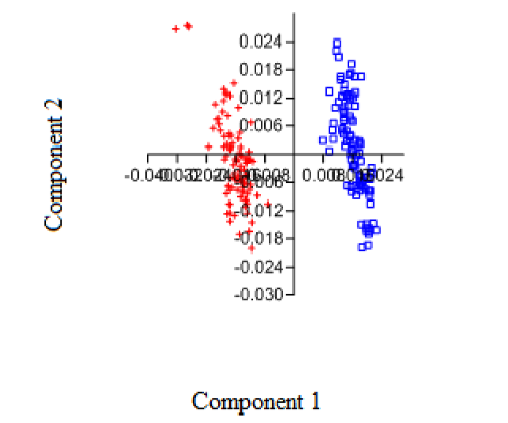


Figure 6. Scatter plot showing relationship between and among CVD [+] and Control (Non-CVD) group [□].

CONCLUSION

The research reveals a significant difference between two groups for individual symmetry and directional asymmetry. Therefore, cardiovascular disease contributes to facial shape changes and that development of facial morphology differ between CVD and non-CVD group.

REFERENCES

Demayo, C.G., Torres, M.A.J. and Veña, C.J. 2010. Face Shapes of Diabetics and Non-Diabetics Described Using Geometric Morphometrics. The Internet Journal of Endocrinology 6(1):1-12.

Mutsvangwa, T. and Douglas, T.S. 2006. Morphometric analysis of facial landmark data to characterize the facial phenotype associated with fetal alcohol syndrome. Journal of Anatomy. vol. 210. pp. 209-220.

Solon, C.C.E., Torres, M.A.J. and Demayo, C.G. 2012. Describing the shape of the face of hypertensive and non-hypertensive adult females using geometric morphometric analysis. HVM Bioflux. 4(1). pp. 45-51.

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