Evaluation of Physiological Changes in Cardiac Function and Structure Associated with Body Surface Area

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In order to detect changes in the structure and functions of the heart produced by disease, it is important to determine the physiological changes in the heart associated with age, sex, race, weight and body surface area. We studied 75 normal healthy subjects to evaluate the physiological changes associated with body surface area. There was high degree of assurance that people included in this study were free of any heart problem. A thorough physical examination was done in each individual and ECG, blood sugar and blood urea was tested in each case. Blood pressure was recorded in each case. Any person showing any abnormality was not included in this study. M-mode and 2D cross-sectional echocardiography was done in each subject. Left ventricular dimension and volume, right ventricular dimension, left atrial size, area of mittral and aortic valves, stroke volume, cardiac output, fractional shortening and ejection fraction were measured in all the subjects. Height and body weight was recorded. With the help of DuBois graph, body surface area was calculated. Individuals were divided into 3 groups group I with body surface area less than 1.5 m^2 . Group II persons having body surface area between 1.5 to 1.7 m^2. Group III included individuals w hose b ody s urface a rea w as more than 1.7 m^2.It was noted that all the parameters increased with increase in body surface area.Systolic and diastolic dimensions of left ventricle, right ventricle, left atrial size and indices of left ventricular function followed a linear regression upon direct linear function of body surface area. The study clearly indicates that relatively higher values in cardiac chamber size and functions in the subjects of higher body surface area do not indicate and abnormality.

Key Words: Body surface area, echocardiography, left ventricular dimensions, stroke volume, ejection fraction.

In order to detect changes in the structure and function of the heart produced by disease it is important to determine the physiological changes in heart associated with age, sex, race, weight and body surface area. Several workers [1, 2, 3] have reported variations in cardiac functions and structure in apparently healthy individuals. They have noted that left ventricular dimensions and wall thickness, left atrial dimension, aortic root size, left ventricular ejection fraction, percent fractional shortening and stroke volume varied according to the body surface area. In most of the studies subjects belonged to western countries who vary in height, weight and body surface area as well as socioeconomic status, when compared with individuals of Pakistan. Present study has also analyzed changes in cardiac functions and structure which occur in Pakistani people of different body surface area.

Material and method:

144 apparently normal subjects were examined for enrollment in this study. They belonged to different socio-economic groups and various professions. The subjects selected were found to be clinically healthy and had no history of hypertension and ischemic heart disease. Thorough clinical examination was done and any s ubject found to have anemia, cyanosis, and edema was not included in this study. Similarly any subject suffering from cardiac disease, respiratory or skeletal abnormality was also excluded from the study. In each case, blood pressure was recorded and subjects having high blood pressure were excluded from the study. Hemoglobin, ESR, blood sugar and blood urea was measured in each case. X – Ray chest and ECG were later obtained from each subject. Any subject showing any abnormality in these investigations was not included. On the basis of these findings 75 normal subjects were selected. Height and weight of each subject was measured at the time of echocardiography. From height and weight recording, body surface area was calculated with the help of Dubois graph[4].

M-mode and 2D cross-sectional echocardiography was d one i n e ach c ase a nd following measurements were made. (i) Left ventricular dimensions and volume (ii) Right ventricular dimensions (iii) Size of left atrium (iv) Septal and posterior wall thickness (v) Size of mitral and aortic valves (vi) Stroke volume, cardiac o utput, e jection fraction and fractional shortening of left ventricle.

Statistical analysis:

Each parameter was analyzed statistically by calculating mean, standard deviation and range for it. The relationship between body surface area and obtained parameter was analyzed by using linear regression graph. Subjects were divided into different groups depending upon body surface area. The mean and standard deviation of each parameter in each group was calculated. The values were reported as mean ± standard deviation.

Results and observations:

75 normal subjects (57 males and 18 females) aged 15 – 50 years w ho w ere f ound c linically n ormal were included in this study. There was high level of assurance that individuals were free of any overt disease. The

characteristics of study population are given in table I. The subjects included in this study varied in their height from 150 – 170 cm, in weight from 40 – 87 kg and in body surface area (BSA) from 1.3 – 2m^2.

Depending upon body surface area, we classified our subjects into three groups. In group I those subjects were placed whose body surface area is less than 1.5 m^2. Group II comprised of 39 subjects whose body surface is between 1.5 to 1.7 m^2. The subjects who had body surface area more than 1.7 m^2 were placed in group III. Parameters of various cardiac chambers and their volume, wall thickness have been given in tables II. While table III describes indices of left ventricular function in various groups.

Analysis of these tables indicate that systolic and diastolic dimensions of left ventricle, systolic and diastolic volume of left ventricle and dimensions of right ventricle increase as body surface area increases. Thickness of inter ventricular septum and posterior wall also increase with increasing body surface area. Ejection fraction, stroke volume, cardiac output and fractional shortening of left ventricle also depends upon body surface area. With increase in body surface area all the parameters were increased.

In order to relate this data with body surface area, we have plotted the figures in this paper so that vertical axis displayed cardiac parameter on arithmetic scale, the horizontal axis was arranged according to linear function body surface area. The relationship between body surface area and the obtained cardiac parameter was then analyzed by using linear regression line (Figures 1 – 7).

Graphical inspection of the data indicated that variability of many of the measurements of cardiac chambers and functions were less at lower body surface area than at higher body surface area. The results of these figures also indicated that internal systolic and diastolic dimensions, left ventricular systolic and diastolic volume, size of right ventricle and three indices of left ventricular function (ejection fraction, stroke volume, and fractional shortening) followed a linear regression upon direct linear function of the body surface area. Mitral and aortic valve areas when plotted against body surface area did not follow a linear relationship, thus these parameters are considered to be independent of body surface area.

Discussion:

Echocardiographic measurements of left ventricular dimensions and wall thickness, aortic root and left atrial dimension, left ventricular ejection fraction, percent fractional shortening and stroke volume are found to increase with body surface area. All parameters follow a linear regression upon direct function of body surface area. These relations appear to be consistent with the study of Henry et al[1]. They studied growth related changes in size of cardiac chambers and their function that occur between infancy to old age and found that all the parameters except ejection fraction and fractional shortening are dependent upon body surface area. He has also observed that internal dimension of left ventricle, left atrium and aortic root varied in a linear relation to the cube root of body surface area. Our data is also consistent with data of Epstein et al[5]. Although not stated in their original paper, subsequent publication of data graphs in text book (Feigenbanm 2002)[6] has included the notation that all the parameters of cardiac dimensions and volume vary depending upon body surface area.

Valdez[7], during a survey of a normal population with the echocardiogram, also concluded that the body surface area adjustments should be done when comparing individual results to normal standards. This study clearly indicates that relatively higher values of cardiac chamber size in the subject with higher body surface area showed no abnormality. Therefore it is recommended that the physicians should consider these differences while making their diagnosis on the basis of echocardiographic measurements in patients with heart disease. By comparing cardiac dimensions and volumes with the standards recommended in this study the status about the normality and the disease may be judged and erratic diagnosis may be avoided.

Table I. Characteristics of study population.

	Mean ± Sd	Range
Age (years)	30±8.7	15 – 50
Height (cm)	160±11.7	150 – 170
Weight (Kg)	61±11.7	40 – 87
Body surface area (m^2)	1.6±0.19	1.3 – 2

Table II. Values for cardiac dimensions and volumes in relation with body surface area (n=75)

	Body surface area (m^2)	Mean ± Sd	Range
LA (mm)	<1.5	33 ± 3	27 – 29
	1.5 – 1.7	34 ± 3	28 – 38
	>1.7	36 ± 4	30 – 41
AO (mm)	< 1.5	27 ± 3	22 – 31
	1.5 – 1.7	31 ± 3	25 - 35
	> 1.7	28 ± 2	24 – 31
RV (mm)	<1.5	15 ± 3	11 – 20
	1.5 – 1.7	17 ± 2	13 – 19
	> 1.7	19 ± 4	13 – 25
IVS thickness (mm)	< 1.5	7 ± 1	6 – 8
	1.5 – 1.7	8 ± 1	7 – 10
	> 1.7	8	6 – 9
LVEDD (m^1)	< 1.5	44 ± 5	36 – 50
	1.5 – 1.7	43 ± 6	25 – 52
	> 1.7	48 ± 5	41 – 53
LVEDV (m^1)	< 1.5	89 ± 26	7 – 125
	1.5 – 1.7	109 ± 28	135 – 118
	> 1.7	117 ± 33	80 – 166
LVESD (mm)	< 1.5	30 ± 4	27 – 30
	1.5 – 1.7	24 ± 4	25 – 35
	> 1.7	29	26 – 35
LVESV (m^1)	< 1.5	29	12 – 36
	1.5 – 1.7	27	18 – 39
	> 1.7	29	18 – 43

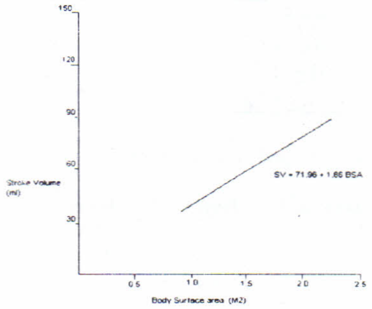
LA = Left atrium; AO = Aorta, RV = Right ventricle; IVS = Interventricular septum; LVEDD = Left ventricular end-diastolic dimension; LVEDV = Left ventricular end-diastolic volume; LVESD = Left ventricular end-systolic dimension; LVESV = Left ventricular end-systolic volume.

TABLE III. Indices of left ventricular functions and the body surface area (n = 75)

Parameter	Body surface area (m2)	Mean + Sd	Range
	< 1. 5	68 + 5	60 – 70
EF	1.5 – 1.7	74 + 6	61 – 80
	> 1.7	69 + 15	38 – 85
	< 1. 5	60 + 17	35 – 82
SV	1.5 – 1.7	75 + 23	51 – 136
	> 1.7	85 + 27	51 – 123
	< 1. 5	32 + 3	27 – 36
FS	1.5 – 1.7	36 + 5	27 – 44
	> 1.7	38 + 4	33 – 45
	< 1. 5	4.9 + 1	3.0 – 7.1
CO (L/min)	1.5 – 1.7	7.4 + 0.1	4 – 8.6
	> 1.7	5.2 + 2	3.3 – 8.4
Aortic valve Opening (cm)	< 1. 5	2.1 + 0.9	1.9 – 2.2
	1.5 – 1.7	2.3	2.0 – 3.6
	> 1.7	3.1 + 0.17	
Mitral valve Area (cm^2)	< 1. 5	3.4	2.7 – 4.4
	1.5 – 1.7	3.6	3.3 – 5
	> 1.7	3.5	3.2 – 4.1
	< 1. 5	7 + 1	6 – 8
LWPWT	1.5 – 1.7	8 + 1	6 – 10
	> 1.7	9 + 1	8 – 9

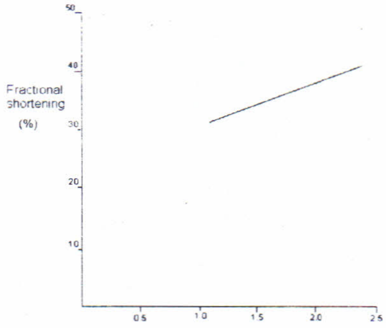
Ef = Ejection fraction; SV = Stroke volume; FS = Fractional shortening; CO = Cardiac output; LVPWT = Left ventricle posterior wall thickness.

Figure No 1



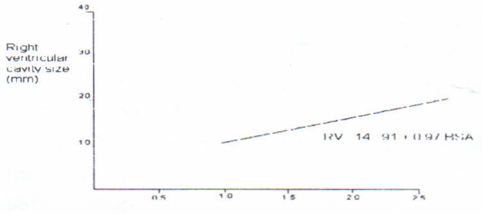
Plot of stroke volume versus A linear function of body surface area.
r = 0.4

Figure No. 2



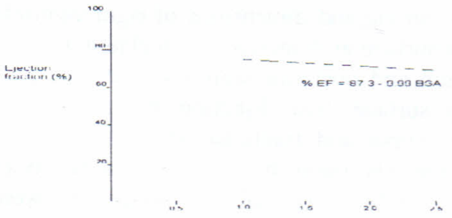
Body surface area (M2)
Linear regression plot depicting the relationship between body surface area and fractional shortening

Figure No 3



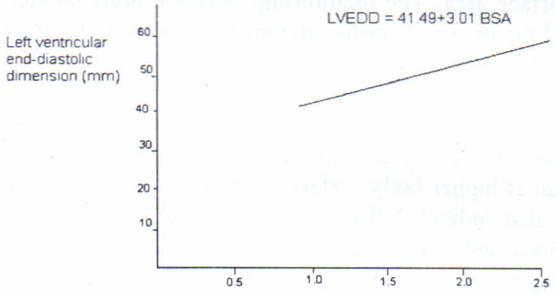
Body surface area (M2)
Linear regression plot depicting the relationship between body surface area and right ventricular dimension
r = 0 5

Figure No 4



Body surface area (M2)
Linear regression plot depicting the relationship between ejection fraction and body surface area
r = 0 4

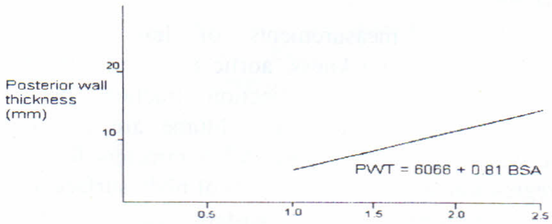
Figure No. 5



Body surface area (M2)

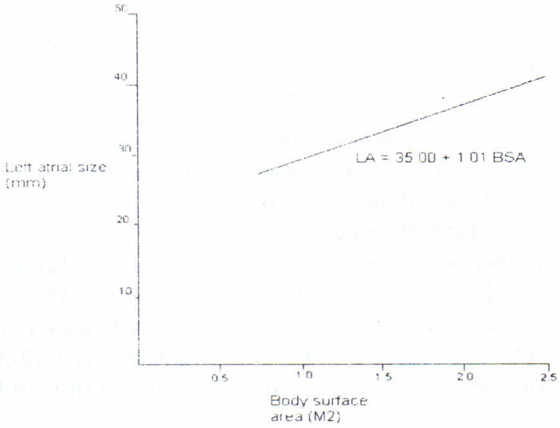
Linear regression plot depicting the relationship between body surface area and left ventricular end-diastolic dimension
r = 0 4

Figure No. 6



Body surface area (M2)
Plot of left ventricular posterior wall thickness versus body surface area
r = 0 51

Figure No 7



Plot of left atrical size versus a linear function of body surface area
r = 0 41

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