Association of Body Composition with Left Ventricular Architecture in Young Healthy Non-obese Adult

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

Article Information

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ABSTRACT

Context: Left ventricular structure and mass is related to body composition. Fat mass as well as fat free mass are known to affect the left ventricular architecture.

Aims: Our goal was to evaluate the relationship between body composition and left ventricular morphology in young healthy non-obese males and females.

Settings and Design: This was the cross sectional study done on 100 (51 male & 49 female) physical education college students.

Methods and Materials: Left ventricular structure was analyzed by 2-D and M-mode echocardiography. Body composition was analyzed using bioelectrical impedance analysis.

Statistical Analysis Used: Pearson correlation analysis and stepwise multiple regression analysis between body composition parameters and left ventricular structure was done using SPSS16 software.

Results: In males, end systolic left ventricular posterior wall thickness (LVPWs) showed significant correlation with weight (r=0.348, p<0.05), BMI (r=0.293, p<0.05), BSA (r=0.314, p<0.05) and fat.

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free mass ($r=0.284$, $p<0.05$). BMI showed significant correlation with end systolic left ventricular internal diameter (LVIDs) ($r=0.309$, $p<0.05$), end diastolic left ventricular mass ($r=0.299$, $p<0.05$) and left ventricular mass ($r=0.370$, $p<0.01$). End diastolic left ventricular septal thickness (IVSd) also showed significant correlation with weight. ($r=0.296$, $p<0.05$) No significant correlation was seen in female subjects.

**Conclusion:** This study showed that the body composition influences some cardiac structural parameters in adult male subjects. However no significant influence was seen in female subjects. Body mass index was shown to have prominent influence on left ventricular structure in males.

**Keywords:** Body composition; left ventricular mass; left ventricular architecture.

1. **INTRODUCTION**

Cardiovascular disorders represent the foremost cause of preventable death globally. According to the World Health Organization (WHO) cardiovascular disease is the number one cause of death globally: more people die annually from cardiovascular disorders than from any other cause. Cardiovascular disease accounts for approximately 30% of all deaths. Hypertension is one of the leading causes of death globally. Besides this epidemic obesity and diabetes are the major health problem all over the world [1].

Alteration in left ventricular morphology is seen in various cardiac and non-cardiac diseases. This alteration may be detected noninvasively by Echocardiography. To identify whether this alteration is normal or abnormal, normal reference standard has to be established. A close correlation is seen between heart parameters and various body size parameters [2, 3,4]. Various body size parameters which had been studied are height, weight, body surface area and body mass index. Studies had advised normalization with respect to these parameters. Body mass index is calculated from body mass and height (body weight / height$^2$). Body mass index has been widely used to classify obesity; however current classification assumes that the relationship between BMI and percentage body fat (fat mass) remains independent of age, gender, ethnicity, and race, but this is not the case. Body mass or body weight comprises of fat mass and fat free mass which may differ according to age, gender, ethnicity, and race. Besides this, lifestyle also affects body composition [5,6,7,8].

People who do regular exercise may have higher fat free mass and person with the sedentary lifestyle may have a higher fat mass. General population display wide variation in lifestyle; some are involved in regular exercise while some have sedentary lifestyle. Thus wide variation in body composition may be seen amongst the population and persons with the same body mass index may have different body composition [8].

We had come across the various studies in athletes and obese persons where body composition was responsible for left ventricular remodelling. Fat free mass was considered to be important predictor of left ventricular mass [9,10, 11,12,13,14]. Studies have been done on nonathletic population where a close correlation of left ventricular mass was seen with fat free mass [5,15]. These studies have been done in the persons with a wide range of BMI and blood pressure for normalization to achieve reference parameter value. With this study, we had made an attempt to evaluate the relationship between body composition and left ventricular morphology in young healthy non-obese males and females without any risk factor i.e. normotensive persons with a normal BMI. Objective of the study was to evaluate whether indexation of left ventricular morphological parameters was required or not in normal population with normal BMI.

2. **SUBJECTS AND METHODS**

The study was conducted after being approved by the institutional ethics committee, GMC, Nagpur. This was the cross sectional study done on 100 (51 male & 49 female) physical education college student in the age group of 17 to 22 years. Written informed consent was taken from the volunteers. Medical history was elicited followed by physical examination. Young healthy, non-smoker volunteers, with the sedentary lifestyle, and with BMI range 18.50 to 24.99 kg/m$^2$ were included in the study. Volunteers were asked about the history of physical activity. Sedentary lifestyle was considered when the total duration of the physical activity is less than 25 minutes per day.[16] Exclusion criteria were as follows-
Exclusion criteria

- Smokers.
- H/o chronic respiratory disease. Subjects with chronic respiratory disease.
- H/o cardiac disease. Subjects with heart disease.
- H/o hypertension. Subjects with hypertension.
- H/o Diabetes. Diabetic subjects.
- H/o Drug intake known to affect body weight/cardiac/respiratory function.
- Examination findings suggestive of preexisting respiratory or cardiac disease.
- Subjects undertaking regular exercise.

Body composition assessment and echocardiography examination were done.

2.1 Body Composition Measurement

Fat mass and fat %. It was determined with a Bioelectrical Impedance Analyzer (BIA) using OMRON BF 300. (Test Medical Symptom @, Inc, 6633, Ashman road, Maria Stein). Metallic objects were removed. Subjects particular were entered, and subjects were trained as to how to hold the machine. Fat mass was shown on the screen and then fat free mass was calculated by deducting fat mass from total mass (weight).

Weight was measured with a digital weighing machine to the nearest 5 gm. Height was measured using the height measuring scale after a subject stood erect with the feet firmly in contact with platform and looking straight ahead in Frankfurt plane to the nearest millimeter. Body surface area (BSA) was estimated through applying height and weight using the equation of Dubois and Dubois [17].

All statistical analyses were performed using SPSS 16 software. Prior to formal statistical testing frequency distributions were tested for normality using the Kolmogorov-Smirnov test. Univariate correlation coefficient (Pearson) was used to examine the relationship between LV structure and body composition. Stepwise multiple regression analysis between body composition parameters and left ventricular parameter was carried out.

3. RESULTS

This study was done on 100 physical education college students, (51 male, 20.02 yrs±1.17; 49 females, 19.77 yrs±1.83). Their characteristics and echocardiographic parameters are shown in Table 1. Association between body composition parameters and left ventricular parameters are shown in Tables 2 and 3.

In males, end systolic left ventricular posterior wall thickness (LVPWs) showed significant correlation with weight (r=0.348, p<0.05), BMI (r=0.293, p<0.05), BSA (r=0.314, p<0.05) and fat free mass (r=0.284, p<0.05). BMI showed
significant correlation with end systolic left ventricular internal diameter (LVIDs) \((r=0.309, p<0.05)\), end diastolic inter ventricular septal thickness (IVSd) \((r=0.299, p<0.05)\) and left ventricular mass \((r=0.370, p<0.01)\). End diastolic inter ventricular septal thickness (IVSd) also showed significant correlation with weight. \((r=0.296, p<0.05)\). In females, no significant correlation between body composition parameters and left ventricular parameters was observed.

Stepwise multiple regression analysis was performed with use of the left ventricular parameters as the dependent variables and height, weight, BMI, BSA, percentage body fat, fat mass, and fat-free mass as the independent variables. It was found that none of the variables entered the regression for predicting left ventricular parameters.

4. DISCUSSION

This study showed the some influence of body composition on adult heart size in males; however no significant influence was shown in females. Body mass index was shown to have prominent significant influence on left ventricular structure in males.

In the present study, parameters which we had studied were height, weight, body surface area, body mass index, fat mass and fat free mass. Body surface area and body mass index are related to height and weight. Body weight or body mass mainly consists of fat free mass and fat mass.

Fat free mass comprises of organ cell mass and non-fatty tissues, including skeletal muscle, tendons, ligaments, and bone. Thus body mass may increase as a result increase in fat free mass.

Table 1. Body composition and left ventricular parameters in the subjects

| Parameters       | Males (n=51) | Females (n=49) |
|------------------|--------------|----------------|
| Age (yrs)        | 20.02±1.17   | 19.77±0.83     |
| Height (m)       | 1.70±0.05    | 1.58±0.05      |
| Weight (kg)      | 60.9±5.9     | 52.2±6.5       |
| BMI (kg/m²)      | 21.04±2.18   | 20.88±2.66     |
| BSA (m²)         | 1.71±0.08    | 1.51±0.1       |
| Fat mass (%)     | 10.7±4.6     | 20.6±4.6       |
| Fat mass (kg)    | 6.60±3.21    | 10.83±3.04     |
| Fat free mass (kg) | 54.25±4.82 | 41.32±5.01     |
| LVPWs(cm)        | 1.4±0.29     | 1.3±0.22       |
| LVIDs(cm)        | 2.9±0.31     | 2.4±0.32       |
| IVSs (cm)        | 1.3±0.3      | 1.3±0.21       |
| LVPWd(cm)        | 1.0±0.19     | 1.0±0.18       |
| LVIDd(cm)        | 4.5±0.39     | 4.1±0.38       |
| IVSd(cm)         | 1.0±0.11     | .9±0.1         |
| EF (%)           | 61.9±9.8     | 66.9±7.8       |
| LV mass (gm)     | 154.45±30.21 | 118.51±19.17   |

Values are mean±S.D.  EF: ejection fraction, IVSd: inter ventricular septal thickness at end-diastole, IVSs: inter ventricular septal thickness at end-systole, LVIDs: left ventricular internal diameter at end-diastole, LVIDd: left ventricular internal diameter at end-diastole, LV mass (gm): left ventricular mass

Table 2. Univariate correlation between body size and composition parameters and left ventricular parameters in males

| Parameters       | LVPWs | LVIDs | IVSs | LVPWd | LVIDd | IVSd | EF  | LV mass |
|------------------|-------|-------|------|-------|-------|------|-----|---------|
| Height           | .036  | -.220 | .100 | -.276 | -.083 | -.055 | .142| -.240   |
| Weight           | .348  | .202  | .144 | .053  | .141  | .296  | .029| .271    |
| BMI              | .293  | .309  | .075 | .190  | .171  | .299  | -.050| .370*   |
| BSA              | .314  | .090  | .165 | -.058 | .079  | .245  | .083| .140    |
| Fat mass (%)     | .136  | .127  | .067 | -.024 | .078  | .160  | .046| .119    |
| Fat mass (kg)    | .210  | .152  | .087 | -.009 | .119  | .201  | .051| .176    |
| Fat free mass    | .284  | .145  | .118 | .071  | .093  | .227  | .001| .213    |

* - p<0.05 significant change, **- p<0.01 very significant change
mass which occur with the exercise and other reason for increase in body mass is obesity where increase in fat mass occurs [20]. Thus body mass index will be high both in athletes as well as in obese persons. Hence we had taken into account fat mass as well fat free mass along with the other variables.

In the older studies, left ventricular morphological parameters were often divided by body surface area to determine their normal range for comparison to detect the presence of pathological left ventricular hypertrophy [5,21]. However these had overestimated left ventricular hypertrophy in the lean subjects and underestimated in obese individuals. Hence height and weight were recommended in place of body surface area [3]. Weight comprises of fat mass and fat free mass. These two parameters may also influence left ventricular remodeling. We had come across some studies where this relation was studied. Left ventricular mass was shown closer relation with the fat free mass in non-athletic population [5,10,15]. No significant relation was found with the fat mass by some authors [4,21]. We also found similar result in males.

How does fat free mass affect left ventricular remodeling? Fat free mass represent the metabolically active tissue. Cardiac output is directly related to the level of metabolism through the tissue demand of oxygen [22,23,24]. Thus increase in fat free mass will be associated with increase in metabolism which in turn would increase the cardiac output and thus cause alteration in then left ventricular morphology [22]. Hence left ventricular morphological parameter had been shown the strong relation with fat free mass in athletic population [9,10].

Can fat mass cause left ventricular remodeling? In some studies in obese person, left ventricular remodeling with or without dysfunction is shown [22,25,26,27,28]. In contrast to fat free mass, adipose tissue (fat mass) is having very less blood supply. [22] thus cardiac output will increase when the amount adipose tissue is very large as occurs in obese person [11,12]. Hence fat mass within normal range will not have any effect on left ventricular morphology in person with no risk factor, which has been supported by our present study. All the subjects were having fat mass within the normal range and they were normotensive.

Thus in the persons with high BMI, left ventricular remodeling may be recorded, however it may not be associated with any dysfunction if high BMI is as a result of exercise and not the obesity. In such case, we need to know body composition.

Why should there be gender difference? There is no significant correlation in females in our study. Hormonal factor may be playing role for this gender difference as growth is the complex phenomenon that is affected not only by growth hormone and somatomedins but also by thyroid hormones, androgen, estrogen, glucocorticoids, and insulin. Besides this genetic factor, nutrition and physical activity may be playing role. Physical activity leads to increase in fat free mass. Correlation of fat free mass with the left ventricular morphology is seen very well in athletes [9,10]. Though we had enquired about physical activity, still there is chance that female volunteers in our study might be less physically active. Physical activity increases the testosterone as well as growth hormone level both in males and females. Both play crucial role in growth and development of the body [29]. For this we recommend further study, with large sample size.

Genetic factor which may play roles are G protein coupled receptor kinase and calmodulin-dependent kinase IV protein. G protein coupled receptor kinase protein (GRK) mediate the adenylyl cyclase activity, this is responsible for β-adrenergic–mediated vasodilation [30].

### Table 3. Univariate correlation between body size and composition parameters and left ventricular parameters in females

| Parameter    | LV PWs | LVIDs | IVSs | LV PWd | LVIDd | IVSd | EF | LV Mass |
|--------------|--------|-------|------|--------|-------|------|----|---------|
| Height       | -.153  | .220  | -.030| -.247  | .092  | -.180| -.122| -.184   |
| Weight       | .058   | .175  | .191 | -.018  | -.026 | .073 | -.050| .009    |
| BMI          | .118   | .073  | .185 | .107   | -.069 | .163 | .011 | .104    |
| BSA          | -.018  | .232  | .151 | -.110  | .012  | -.013| -.091| -.066   |
| Fat mass (%) | .145   | -.054 | .061 | .027   | .162  | -.005| .240 | .163    |
| Fat mass (kg)| .148   | .051  | .141 | .004   | .113  | .046 | .128 | .132    |
| Fat free mass| -.015  | .197  | .162 | -.027  | -.103 | .066 | -.143| -.068   |

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Calmodulin-dependent kinase IV also regulates vasodilation through the action on endothelial nitric oxide [31]. These function gets affected in hypertension. Generalized defect in vascular GRK-2 protein and Calmodulin-dependent kinase IV expression was observed in different rat and mice models hypertension. Also GRK-5 with amino terminus (GRK-5 NT) had been shown to inhibit left ventricular hypertrophy. This effect is through inhibiting NF-κB dependent hypertrophic gene expression [32]. Thus these genes may control left ventricular hypertrophy either directly or through the alteration in vascular function.

Physical activity affect body composition and also it may up-to certain extent is responsible for left ventricular remodeling, thus we should have used physical activity questionnaire to know the accurate history of any physical activity. Our sample size was less. Because of small sample size, there is possibility of selection bias, and thus larger population needs to be evaluated. We could have included other parameters like hemoglobin, waist/hip ratio and lipid profile as these factors directly affects hemodynamic profile of the body and thus may alter body composition and left ventricular morphology.

Another limitation from clinical point of view is that in this project, only one of the parameters (ejection fraction) which would give idea about left ventricular function was included. Ralph K et al. [33] had stressed the importance of functional assessment in case of abnormal left ventricular morphology. Thus in this study we should have included all parameters which would help in left ventricular functional assessment. This would have given us better insight on effect of body composition on left ventricular function. We advocate further studies in future keeping all these factors in mind.

5. CONCLUSION

To conclude, some influence of body composition on adult heart size was observed in males; however no significant influence was shown in females. Body mass index was shown to have prominent influence on left ventricular structure compared to fat free mass in males. Indexation of left ventricular morphology parameter by fat free mass may not be required in persons with the normal BMI without any risk factor. Further studies are recommended with the large sample size.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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