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# Relation of metabolic syndrome components to left ventricular mass in Mexican Americans versus non-Hispanic whites

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**Abstract**

Metabolic syndrome (MetS) is associated with increased risk for cardiovascular disease (CVD). Mexican Americans (MA) exhibit increases in CVD risk factors compared with non-Hispanic whites (NHW), but few data exist comparing the relation of MetS to subclinical CVD, for example, left ventricular (LV) mass. Asymptomatic subjects (104 MA and 101 NHW, 52.2% female, aged 48 ± 12 years) were studied by echocardiography (echo) and by blood and urine tests. *Metabolic syndrome* was defined based on the American Heart Association/National Heart, Lung, and Blood Institute definition. Echo LV mass was compared with the presence or absence of MetS and with the number of MetS components. Multiple linear regression also examined the association of MetS with LV mass adjusted for non-MetS risk factors. Left ventricular mass was lower in MA (145.5 ± 43.9 g) compared with NHW (160.2 ± 49.9 g) ($P < .05$), although this difference was attenuated after adjusting for MetS and other risk factors. Left ventricular mass was higher in those with vs without MetS in both MA and NHW men and women ($P < .05$ to $P < .01$). There was a significant ($P < .001$) graded increase in echo LV mass with increasing number of MetS components both in MA (108.3 to 153.8 g) and NHW (144.3 to 215.1 g). In multiple regression analysis, male sex and MetS remained independently associated ($P < .0001$) with LV mass; however, body mass index explained much of this association, indicating the strong association of obesity with LV mass. Mean LV mass in both MA and NHW adults was higher in those with vs without MetS and with increasing number of MetS components, with body mass index the principal component of MetS associated with LV mass. The prognostic significance of LV mass in persons with MetS requires further study.


## 1. Introduction

Metabolic syndrome (MetS) and the number of MetS risk factors are associated with an increased risk of cardiovascular disease (CVD) and all-cause mortality [1-3]. The association of increased left ventricular (LV) mass and LV hypertrophy with the incidence of CVD is also well established [4,5]. Recently, data have been reported on the association of MetS with LV mass, including data in African Americans [6] and in hypertensive subjects [7]. There are no reported data regarding the association MetS and MetS risk factors with LV mass in Mexican Americans (MA), how this compares to non-Hispanic whites (NHW), and whether MetS is an independent risk factor for LV mass in these groups.

In this study, we sought to test the hypotheses that (1) MetS and the burden of MetS risk factors are related to echocardiographic (echo) LV mass and (2) these relations differed between MA and NHW.

## 2. Methods

### 2.1. Subjects

Asymptomatic community-based adult volunteers were enrolled from the greater Southern California and Detroit areas [8]. We studied 104 adult MA (39 men and 63 women;

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mean age, 47.1 ± 13.5 years) and 101 NHW (59 men and 42 women; age, 49.6 ± 10.8 years) volunteers using blood tests, transthoracic echo, and brachial arterial flow-mediated dilatation by ultrasound. Subjects were generally healthy: individuals with hypertension or known CVD or taking cardiovascular or blood pressure (BP) medications were excluded. To qualify for inclusion, subjects had to be classified as MA according to at least one of the following criteria used in the San Antonio Heart Study [9]: (1) father's surname and mother's maiden name are both Spanish, and both parents were born in Mexico; and/or [2] only 1 parent has a Spanish surname, but 3 of 4 grandparents have Mexican origins.

### 2.2. Echocardiography

This study used the echo protocol used in both the Cardiovascular Health Study [10] and Coronary Artery Risk Development in Young Adults studies [11]. For each subject, a baseline echo was recorded using a standardized protocol. Two-dimensionally guided M-mode echo measurements of the LV were made according to conventions of the American Society of Echocardiography. Left ventricular mass was derived from the formula described by Devereux et al [12,13]:

$$\text{LV mass (in grams)} = 0.8 \times 1.04\left[(\text{VSTd} + \text{LVIDd} + \text{PWTd})^3 - (\text{LVIDd})^3\right] + 0.6$$

where VSTd is the ventricular septal thickness at end diastole, LVIDd is the LV internal dimension at end diastole, and PWTd is the LV posterior wall thickness at end diastole.

Left ventricular mass was also normalized for height and body surface area (BSA) by dividing LV mass by height$^{2.7}$ and by BSA.

### 2.3. Demographic and risk factors

Demographic and risk factor measures included age, sex, ethnicity, fasting blood glucose and lipids, BP, smoking, and (height and weight to calculate) body mass index (BMI). *Metabolic syndrome* was defined if at least 3 of the following factors were present, according to a modified definition based on the most recent American Heart Association/National Heart, Lung, and Blood Institute criteria [14]:

- Triglycerides of at least 150 mg/dL;
- High-density lipoprotein (HDL) cholesterol less than 50 mg/dL (women) and less than 40 mg/dL (men);
- Body mass index of at least 30 kg/m$^2$ for men and at least 25 kg/m$^2$ for women;
- Blood pressure of at least 130/85 mm/Hg or on medication; or
- Fasting blood glucose of at least 100 mg/dL or on medication for glucose.

### 2.4. Statistical analyses

Analyses were performed using SAS statistical software (SAS Institute, Research Triangle Park, NC). Risk factors, LV mass, and MetS prevalence were compared between MA and NHW using the Student $t$ test or $\chi^2$ test for proportions, as appropriate. Left ventricular mass was examined in relation to the number of MetS risk factors (0, 1, 2, or 3+ defining MetS) in both MA and NHW. Multiple linear regression was used to examine whether MetS was independently associated with LV mass after adjustment for age, sex, ethnicity, and the non-MetS risk factors of total cholesterol and smoking. An interaction term of MetS and ethnicity was also tested to see whether relationships of MetS with LV mass differed according to ethnicity. Furthermore, in a secondary analysis, we investigated whether MetS remained associated with LV mass over and above its component risk factors.

## 3. Results

Comparing MA with NHW, MA were significantly ($P <$ .05 to $P <$ .01) more likely to be female, had higher BMI and triglycerides, and a greater prevalence of MetS (Table 1). In addition, mean unadjusted LV mass was significantly lower in MA compared with NHW, both in those with and in those without MetS, and significantly higher in those with vs without MetS in both MA and NHW (Fig. 1). There was also a significant and graded increase in LV mass by number of MetS risk factors in both MA ($P$ = .0029) and NHW ($P$ = .01) (Fig. 2). In the overall cohort, however, there was no significant difference in MA vs NHW when LV mass was indexed to body height or to BSA (Table 1).

Table 2 shows associations of risk factors with LV mass, unadjusted and indexed by height and BSA. Age was positively associated with LV mass indexed by height or

Table 1
Descriptive statistics

| | MA (n = 104) | NHW (n = 101) |
|---|---|---|
| Age (y) | 47.1 ± 13.5 | 49.7 ± 10.8 |
| % Female | 62.5%† | 41.6% |
| Total cholesterol (mg/dL) | 200.9 ± 35.0 | 203.2 ± 37.4 |
| HDL cholesterol (mg/dL) | 53.5 ± 13.3 | 54.0 ± 13.2 |
| Triglycerides (mg/dL) | 182.1 ± 121.7† | 124.3 ± 66.6 |
| Systolic BP (mm Hg) | 125.8 ± 17.0 | 125.1 ± 14.4 |
| Diabetes (%) | 7.7% | 6.9% |
| Smoking (%) | 6.7% | 5.9% |
| Glucose (mg/dL) | 90.7 ± 13.7 | 88.6 ± 21.6 |
| BMI (kg/m$^2$) | 30.6 ± 6.9† | 27.7 ± 4.2 |
| % MetS | 35.5%† | 19.8% |
| LV mass (g) (unadjusted) | 145.5 ± 49.3* (n = 103) | 160.2 ± 49.9 |
| LV mass/height$^{2.7}$ | 38.9 ± 10.4 (n = 103) | 36.7 ± 8.7 |
| LV mass/BSA | 77.6 ± 18.1 (n = 103) | 81.1 ± 18.7 |

* $P <$ .05 compared with NHW.
† $P <$ .01 compared with NHW.

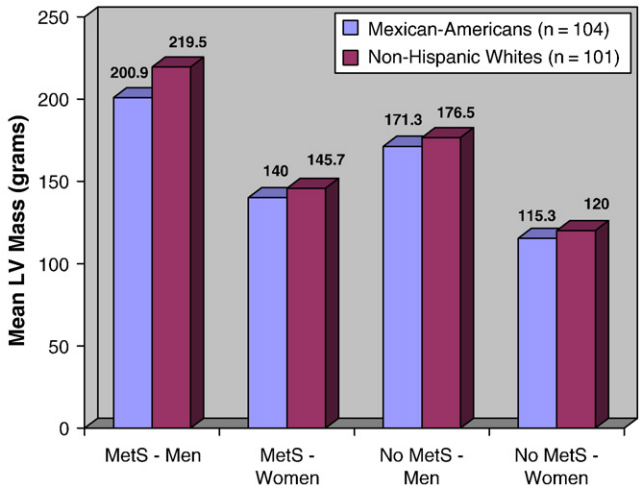


Fig. 1. Mean LV mass by presence of MetS. Comparisons between those with vs without MetS for LV mass: NHW women ($P < .05$), NHW men ($P < .01$), MA women ($P < .01$), and MA men ($P < .05$).

BSA, and men had greater LV mass compared with women by either of the 3 measurements. High-density lipoprotein cholesterol bore significant inverse association with each LV mass measure, as did both systolic and diastolic BP. Glucose and BMI were also positively associated with each of the 3 LV mass measures; however, smoking and diabetes were not (Table 2).

In multiple linear regression analyses (Table 3), MetS and male sex were independently and consistently associated with increased LV mass, unadjusted as well as indexed for height and BSA; age was also associated with LV mass indexed by height and BSA, but not unadjusted LV mass. There was no consistent difference in LV mass by ethnicity in multivariable analysis, and an interaction term of MetS with ethnicity showed that this relation to LV mass did not differ between MA and NHW (Table 3). Moreover,

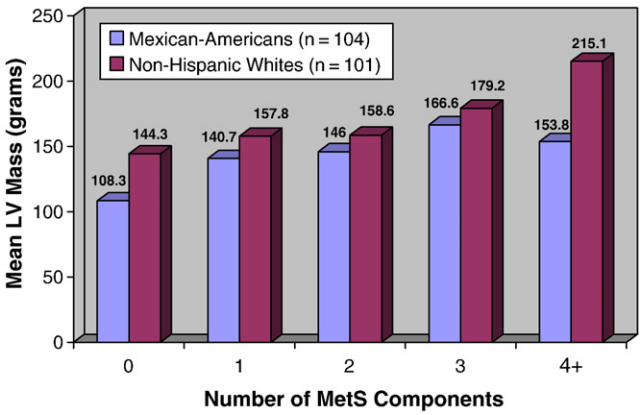


Fig. 2. Mean LV mass (in grams) by number of MetS risk factors. For MA vs NHW: $P < .01$ for 0 component, $P = .20$ for 1, $P = .35$ for 2, $P = .07$ for 3, and $P = .04$ for 4+ components. Across number of MetS components: $P = .0029$ for MA and $P = .01$ for NHW.

Table 2
Levels of LV mass by risk factor and associations of risk factors with LV mass

| | Unadjusted LV mass | LV mass/height$^{2.7}$ | LV mass/BSA |
|---|---|---|---|
| Gender (male/female) | 183.8 ± 44.3/ 124.6 ± 29.1 | 40.5 ± 10.1/ 35.3 ± 8.5 | 89.0 ± 18.6/ 70.5 ± 13.2 |
| Smoking (yes/no) | 150.6 ± 54.8/ 146.2 ± 47.0 | 38.3 ± 9.6/ 37.8 ± 9.6 | 78.6 ± 19.8/ 79.4 ± 18.4 |
| Diabetes (yes/no) | 144.1 ± 44.9/ 153.3 ± 47.8 | 40.2 ± 12.0/ 37.6 ± 9.4 | 78.7 ± 16.9/ 79.3 ± 18.6 |
| Age (y) | 0.073 | 0.21** | 0.17* |
| Total cholesterol (mg/dL) | −0.043 | 0.008 | −0.055 |
| HDL cholesterol (mg/dL) | −0.39*** | −0.23*** | −0.25*** |
| Triglycerides (mg/dL) | 0.12 | 0.15* | 0.06 |
| Systolic BP (mm Hg) | 0.39*** | 0.46*** | 0.41*** |
| Diastolic BP (mm Hg) | 0.47*** | 0.37*** | 0.39*** |
| Glucose (mg/dL) | 0.20** | 0.22** | 0.17* |
| BMI (kg/m$^2$) | 0.40*** | 0.52*** | 0.21*** |

* $P < .05$ (comparing mean values for binary variables or for correlations).
** $P < .01$ (comparing mean values for binary variables or for correlations).
*** $P < .001$ (comparing mean values for binary variables or for correlations).

relationships of MetS with LV mass were robust and essentially unchanged even after excluding subjects with diabetes, indicating that the relation of MetS with LV mass was not dependent on subjects with diabetes (results not shown). In an additional regression analysis, the presence of MetS remained significantly associated (coefficient, 28.3; $P < .001$) with LV mass after additionally adjusting for the MetS risk factors of elevated glucose, BP, triglycerides, and low HDL-C; however, after the additional adjustment for BMI, this was completely attenuated and no longer significant (coefficient, 8.8; $P = .34$). Left ventricular mass

Table 3
Multiple linear regression of risk factors for LV mass

| | Unadjusted LV mass (coefficient) | LV mass/height$^{2.7}$ (coefficient) | LV mass/BSA (coefficient) |
|---|---|---|---|
| Intercept | 126.5 | 25.6 | 63.3 |
| Age (per y) | 0.34 | 0.17‡ | 0.30† |
| Sex (male vs female) | 59.7‡ | 6.41‡ | 19.34‡ |
| Ethnicity (MA vs NHW) | −4.16 | 3.48* | 1.29 |
| Total cholesterol (per mg/dL) | −0.12 | −0.013 | −0.05 |
| Smoking (any vs none) | 0.37 | 0.45 | −0.33 |
| MetS (yes vs no) | 34.7‡ | 6.66† | 9.30* |
| MetS ethnicity interaction term | −7.4 | −1.42 | −3.84 |

* $P < .05$.
† $P < .01$.
‡ $P < .001$.

indexed by height and BSA was expectedly attenuated more from adjustment with other MetS risk factors, especially BMI. Also of interest was to examine the association of MetS and LV mass in persons with both lower BMI (<25 kg/m$^2$ in women and <30 kg/m$^2$ in men) and higher BMI (above these cut points, comprising 53% of participants). Although MetS was associated with LV mass in both groups, adjustment for BMI attenuated these relationships in both groups (results not shown). Finally, we sought to examine whether the relation of MetS and its components with LV mass was similar among men and women by using an interaction term of sex with MetS and each of the components. We found no interactions, with the exception of unadjusted LV mass with sex ($P < .01$, with men with MetS having a 2.46 g greater LV mass than women with MetS).

## 4. Discussion

In the present study, the presence of MetS, as well as its number of components, was independently associated with increased LV mass in both MA and NHW. Mean LV mass was significantly higher in those with vs without MetS in both MA and NHW. Moreover, we demonstrate MetS to be associated with increased LV mass (unadjusted) even after adjustment for other risk factors and most MetS components, with the exception of BMI, which when additionally adjusted for appears to explain most of the strong relation of MetS with increased LV mass. This indicates that obesity is the most important component of MetS that explains its relation with increased LV mass.

Similarly, in a study of African Americans from the Jackson, MI, Field Center of the Atherosclerosis Risk in Communities study, LV mass indexed by height increased in a stepwise gradient with increasing number of MetS components in both men and women [6]. In the Atherosclerosis Risk in Communities study, the components of LV mass significantly associated with the number of MetS components were LV posterior wall and interventricular septal thickness, but not LV internal dimension. In an echo study in American Indians (the Strong Heart Study), the investigators found that participants with MetS had greater LV mass, internal dimension, and relative wall thickness with lower LV ejection fraction than those without MetS [15]. These workers found that increased BP was the component of MetS most strongly associated with increased LV mass. In the current study, in MA, systolic BP and BMI were both positively associated, whereas HDL cholesterol was negative associated, with LV mass.

Metabolic syndrome is well known to be associated with risk for CVD. In a review of prospective studies of general populations from 1998 to 2004, Ford [2] found that the population-attributable fraction for the MetS was approximately 6% to 7% for all-cause mortality and 12% to 17% for CVD. Recently, investigators from the Hypertension Genetic Epidemiology Network were able to identify gene loci related to crucial MetS and LV geometry risk factors that contribute to the risk of developing heart disease [16]. In a report from the Third National Health and Nutrition Examination Survey, Li and associates [17] demonstrated that MetS was associated with about a 2-fold increased likelihood of self-reported heart failure and suggested that MetS might serve as a surrogate indicator for the known association between insulin resistance and heart failure.

### 4.1. Limitations

As expected, the cross-sectional nature of this study precludes the ability to examine the impact of MetS on the development of LV hypertrophy and/or the progression of LV mass. In addition, without follow-up for cardiovascular events, we were unable to show whether reported increases in cardiovascular risk from MetS are mediated by increases in LV mass. Finally, our relatively modest sample size and relatively few subjects with diabetes precluded our ability to examine the comparative association of both diabetes and MetS in relation to increased LV mass. In a separate analysis excluding subjects with diabetes, however, MetS was still a strong predictor of LV mass independent of other non-MetS risk factors. Finally, we did not make other specialized measurements that would have been of interest to examine as potential explanatory factors for the relation of MetS with LV mass, including measures of inflammatory cytokines, oxidation, insulin, or adiponectin levels.

### 4.2. Conclusions

Metabolic syndrome is associated with increased LV mass both in MA and in NHW, and there is a significant gradient of increased LV mass associated with an increasing number of MetS risk factors. Moreover, although the association of MetS with unadjusted LV mass appears to be independent of most other MetS and non-MetS risk factors, obesity (indicated by BMI in this study) is the principal component of MetS that explains this relationship to LV mass. Importantly, the prognostic significance of LV mass in persons with MetS requires further investigation, particularly in ethnic minority groups.

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