Racial Differences in the Age-Related Increase in Left Ventricular Mass in Youths

Gregory A. Harshfield, David W. Koelsch, Derrick A. Pulliam, Bruce S. Alpert, Phyllis A. Richey, Judith A. Becker

Abstract We determined the factors related to left ventricular mass adjusted for body size in 60 black (mean age, 13±2 years) and 40 white (mean age, 14±2 years) normotensive youths. The factors examined included age, sex, systolic blood pressure, diastolic blood pressure, plasma aldosterone concentration, and sodium and potassium intake as determined by 24-hour excretion. Sex (β=13.3, P<.003), age (β=2.88, P<.001), and systolic blood pressure (β=0.41, P<.02) were independent predictors in the sample as a whole, accounting for 37% of the variance of left ventricular mass adjusted for height. Separate analyses were performed for black and white subjects. In the black subjects, age (β=4.4, P<.004) followed by sex (β=11.85, P<.02) were independent factors, accounting for 43% of the variance of left ventricular mass adjusted for height. In contrast, in white subjects systolic blood pressure (β=0.4, P<.003) followed by sodium excretion (β=0.13, P<.05) were independent factors, with gender (β=8.89, P<.07) tending to account for 36% of the variance. Similar results were observed for left ventricular mass adjusted for body surface area. In conclusion, the age-related increase in adjusted left ventricular mass in black but not white youths may in part account for the early development of cardiovascular disease among the black population. (Hypertension. 1994;24:747-751.)

Key Words • left ventricular mass • racial differences • blood pressure • sex differences • sodium excretion

Left ventricular hypertrophy (LVH) is a recognized risk factor for the development of morbidity cardiovascular events. Studies in adults have identified several factors related to left ventricular mass (LVM) and LVH, including age, sex, body size, blood pressure (BP), electrolytes, plasma renin activity (PRA), and exercise capacity. Furthermore, studies in adults have found that the black relative to the white population is characterized by a greater LVM and a greater prevalence of LVH. It has been hypothesized that this difference contributes to the greater cardiovascular morbidity and mortality among the black population. In contrast, studies in pediatric populations and young adults have not observed racial differences in LVM. The purpose of this study was to identify factors related to LVM in healthy, normotensive black and white youths.

Methods

Subject Characteristics

The protocol was approved by the Institutional Committee on Human Research and the Clinical Research Center Scientific Advisory Board. Written informed parental consent was obtained before testing. The study population consisted of 100 healthy, normotensive subjects. The subjects, part of a larger study examining cardiovascular risk factors in youth, were recruited through local advertising. Race was determined by self-report. The factors examined included age, sex, systolic BP (SBP), diastolic BP (DBP), PRA, plasma aldosterone concentration (PAC), 24-hour urinary sodium excretion (U\textsubscript{Na}V), and 24-hour urinary potassium excretion (U\textsubscript{K}V). Table 1 lists the subject characteristics and baseline information.

Procedures

The subjects reported to the Pediatric Clinical Research Center on the morning of the day of testing. A history was taken from the child and/or parent to rule out the presence of cardiovascular disease. BP was then obtained, an echocardiogram was performed, and blood samples were drawn. The subjects were given instructions (written and verbal) for the collection of a 24-hour urine sample for the determination of U\textsubscript{Na}V, U\textsubscript{K}V, and creatinine.

Echocardiogram

An M-mode echocardiogram was performed to determine LV mass. The echocardiogram was obtained with an IREX 730 (Aloka Co Ltd) ultrasonoscope with a 3.0-MHz mechanical transducer, an electrocardiogram monitor, and a Honeywell on-line thermal strip-chart recorder. The subject was placed in the left lateral decubitus position. The parasternal short axis window was used (standard intercostal space technique). An M-mode tracing was obtained at the level of the mitral valve tips, maximally magnified, and recorded at a paper speed of 50 mm/s. LVM was calculated by using the American Society of Echocardiography convention with measurements taken at end diastole, defined by the q-wave on the electrocardiogram trace. It is the convention to adjust LVM by an index of body size. Height and body surface area (BSA) are used most frequently. However, there is not a consensus as to which is the most appropriate index, particularly in youths. Therefore, LVM was adjusted for both height (LVM/height) and BSA (LVM/BSA).

Blood Pressure

The methods used in our laboratory for the measurement of baseline BP have been described in detail. Briefly, BP was measured with a Dinamap BP monitor (Model 1846SX, Critikon) that was checked against measurements obtained by a technician using a mercury column and stethoscope to ensure...
TABLE 1. Subject Characteristics and Casual Measurements

<table>
<thead>
<tr>
<th>Variable</th>
<th>Blacks</th>
<th>Whites</th>
<th>Total</th>
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<tbody>
<tr>
<td>Sample size</td>
<td>60</td>
<td>40</td>
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<tr>
<td>Boys/girls</td>
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<td>21/19</td>
<td>53/47</td>
</tr>
<tr>
<td>Age, y</td>
<td>13±2</td>
<td>14±2</td>
<td>13±2</td>
</tr>
<tr>
<td>Height, m</td>
<td>1.6±1.3</td>
<td>1.6±1.3</td>
<td>1.6±1.2</td>
</tr>
<tr>
<td>Weight, kg</td>
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<td>53±16</td>
<td>53±16</td>
</tr>
<tr>
<td>BSA, m²</td>
<td>1.55±0.28</td>
<td>1.53±0.27</td>
<td>1.54±0.27</td>
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<tr>
<td>SBP, mm Hg</td>
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<td>108±11</td>
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<tr>
<td>DBP, mm Hg</td>
<td>64±8</td>
<td>66±8</td>
<td>65±8</td>
</tr>
<tr>
<td>PRA, ng • mL⁻¹ • h⁻¹</td>
<td>2.3±1.8</td>
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<tr>
<td>PAC, ng/mL</td>
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<td>12.5±8.5</td>
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<tr>
<td>UaV, mmol/24 h</td>
<td>106±44</td>
<td>109±38</td>
<td>107±42</td>
</tr>
<tr>
<td>U₁V, mmol/24 h</td>
<td>28±12</td>
<td>26±14</td>
<td>27±13</td>
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<tr>
<td>Septal wall thickness, cm</td>
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<td>0.2±0.02</td>
<td>0.2±0.02</td>
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<tr>
<td>Posterior wall thickness, cm</td>
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<td>0.9±0.2</td>
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<tr>
<td>LVM/height, g/m</td>
<td>78±17</td>
<td>74±15</td>
<td>77±16</td>
</tr>
<tr>
<td>LVM/BSA, g/m</td>
<td>76±22</td>
<td>71±18</td>
<td>74±21</td>
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</table>

BSA indicates body surface area; SBP, systolic blood pressure; DBP, diastolic blood pressure; PRA, plasma renin activity; PAC, plasma aldosterone concentration; UaV, sodium excretion; U₁V, potassium excretion; and LVM, left ventricular mass.

Results

All Subjects

Boys compared with girls had greater LVM/height (81±21 versus 66±16 g/m, P<.0002) and LVM/BSA (83±17 versus 70±12 g/m², P<.001). Simple regression demonstrated that age was related to LVM/height (β=3.86, r=.41, P<.0001) and LVM/BSA (β=1.89, r=.25, P<.01). In addition, SBP was related to LVM/height (β=0.79, r=.43, P<.001) and LVM/BSA (β=0.45, r=.31, P<.002). Finally, UaV was related to LVM/height (β=0.16, r=.33, P<.001) and LVM/BSA (β=0.08, r=.2, P<.05). Multiple regression demonstrated that sex, age, and SBP contributed independently to the model for LVM/height (Table 2), with a multiple R²=.37 (P<.0001). Sex and age only contributed independently to the model for LVM/BSA, with a multiple R² of .25 (P<.0001).

Blacks

Black boys compared with black girls had greater LVM/height (Fig 1) and LVM/BSA (85±17 versus 71±14 g/m², P<.001). Simple regression demonstrated that age, SBP, and UaV were related to LVM/height (Fig 2). Age (β=3.69, r=.45, P<.0003), SBP (β=0.45, r=.30, P<.02), and UaV (β=0.1, r=.26, P<.04) also were related to LVM/BSA. Multiple regression demonstrated that age and sex contributed independently to the model for LVM/height (Table 2), with a multiple R²=.43 (P<.001). Age and sex contributed independently to the model for LVM/BSA (Table 2), with a multiple R²=.32 (P<.002).

Whites

The difference in LVM/BSA between boys and girls was significant (80±16 versus 69±11 g/m², P<.02), and
TABLE 2. Multiple Regression Models for Left Ventricular Mass Indexed by Height and Body Surface Area

<table>
<thead>
<tr>
<th>Variable</th>
<th>Total sample</th>
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<td></td>
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<td>SEM</td>
<td>P</td>
<td>Coefficient</td>
<td>SEM</td>
<td>P</td>
<td></td>
<td></td>
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<td>Sex (girls, 0; boys, 1)</td>
<td>13.33</td>
<td>3.54</td>
<td>.0003</td>
<td>12.16</td>
<td>3.08</td>
<td>.0001</td>
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<td>Age, y</td>
<td>2.88</td>
<td>0.86</td>
<td>.001</td>
<td>1.45</td>
<td>0.75</td>
<td>.05</td>
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<td>SBP, mm Hg</td>
<td>0.41</td>
<td>0.17</td>
<td>.02</td>
<td>0.26</td>
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<td>UN(_{\text{V}}), mEq/24 h</td>
<td>0.05</td>
<td>1.98</td>
<td>NS</td>
<td>-0.004</td>
<td>0.39</td>
<td>NS</td>
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<th></th>
<th>Coefficient</th>
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<th>P</th>
<th>Coefficient</th>
<th>SEM</th>
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<tr>
<td>Age, y</td>
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<td>2.84</td>
<td>0.98</td>
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<td>Sex (girls, 0; boys, 1)</td>
<td>11.85</td>
<td>4.92</td>
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<td>10.40</td>
<td>4.18</td>
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<td>UN(_{\text{V}}), mEq/24 h</td>
<td>0.04</td>
<td>0.06</td>
<td>NS</td>
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<td>SBP, mm Hg</td>
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<td>0.23</td>
<td>NS</td>
<td>0.14</td>
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Whites

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<th>SEM</th>
<th>P</th>
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<tbody>
<tr>
<td>SBP, mm Hg</td>
<td>0.7</td>
<td>0.22</td>
<td>.003</td>
<td>0.42</td>
<td>0.2</td>
<td>.04</td>
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<tr>
<td>Sex (girls, 0; boys, 1)</td>
<td>8.89</td>
<td>4.77</td>
<td>.07</td>
<td>10.32</td>
<td>4.34</td>
<td>.02</td>
</tr>
<tr>
<td>UN(_{\text{V}}), mEq/24 h</td>
<td>0.13</td>
<td>0.06</td>
<td>.05</td>
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</table>

LVM indicates left ventricular mass; BSA, body surface area; SBP, systolic blood pressure; UN\(_{\text{V}}\), sodium excretion; and NS, not significant.

Sex, age, and SBP had independent effects on LVM/height for the group as a whole. Sex and age also had independent effects on LVM/BSA. Specifically, boys, older subjects, and those with higher SBP had greater LVM/height. Boys and older subjects had higher LVM/BSA, with a trend for those with higher SBP. These results are consistent with those of many previous studies in both adults and youths. For example, Daniels et al\(^{24}\) reported the independent effects of sex and SBP on LVM/height in a cohort of children and adolescents. Goble et al\(^{33}\) reported greater LVM/BSA for boys relative to girls from the Medical College of Virginia Twin Study. The Muscatine Study\(^{34}\) divided subjects into quintiles of BP and found that the highest quintile had the greatest LVM corrected for age, sex, height, weight, and tricep skin-fold thickness. More recently,\(^{35}\) this group found significant effects of age, sex, height, weight, and BP on LVM. Levy et al\(^{12}\) reported independent associations between LVM/height and both age and BP in a study of adults from the Framingham Heart Study. Hammond et al\(^{36}\) reported the independent effects of SBP, age, and sex in a study of adult patients with essential hypertension.

The black and white subjects in our study had similar LVM adjusted for height and BSA. These results are consistent with those of the few studies on subjects of similar age. Burke et al\(^{22}\) reported similar LVM/BSA for black and white subjects 7 to 22 years of age from the Bogalusa Heart Study. Daniels et al\(^{23}\) found similar differences in LVM/height for black and white subjects were not significantly different from each other for the relations between either SBP or UN\(_{\text{V}}\) and LVM/height or LVM/BSA. Finally, the race-by-sex interaction was not significant for LVM/height or LVM/BSA, indicating that black and white subjects had similar relations between sex and both LVM/height and LVM/BSA.

**Discussion**

Sex, age, and SBP had independent effects on LVM/height for the group as a whole. Sex and age also had independent effects on LVM/BSA. Specifically, boys, older subjects, and those with higher SBP had greater LVM/height. Boys and older subjects had higher LVM/BSA, with a trend for those with higher SBP. These results are consistent with those of many previous studies in both adults and youths. For example, Daniels et al\(^{24}\) reported the independent effects of sex and SBP on LVM/height in a cohort of children and adolescents. Goble et al\(^{33}\) reported greater LVM/BSA for boys relative to girls from the Medical College of Virginia Twin Study. The Muscatine Study\(^{34}\) divided subjects into quintiles of BP and found that the highest quintile had the greatest LVM corrected for age, sex, height, weight, and tricep skin-fold thickness. More recently,\(^{35}\) this group found significant effects of age, sex, height, weight, and BP on LVM. Levy et al\(^{12}\) reported independent associations between LVM/height and both age and BP in a study of adults from the Framingham Heart Study. Hammond et al\(^{36}\) reported the independent effects of SBP, age, and sex in a study of adult patients with essential hypertension.

The black and white subjects in our study had similar LVM adjusted for height and BSA. These results are consistent with those of the few studies on subjects of similar age. Burke et al\(^{22}\) reported similar LVM/BSA for black and white subjects 7 to 22 years of age from the Bogalusa Heart Study. Daniels et al\(^{23}\) found similar
levels of LVM/height for black and white subjects 6 to 23 years of age. Also, Daniels et al\textsuperscript{24} reported similar prevalence rates of LVH for black and white children and adolescents. In addition, Hindertiter et al\textsuperscript{25} reported similar LVM/BSA for black and white subjects with a mean age of 30 years. The results of these studies in youths and young adults are in contrast to those of studies in older populations. These studies demonstrated increased LVM/BSA and prevalence of LVH in black relative to white subjects. Dunn et al\textsuperscript{16} examined 30 black and 30 white adult patients matched for age, sex, and mean BP. Black subjects had significantly greater LVM/BSA than white subjects. Hammond et al\textsuperscript{36} reported that the prevalence of LVH was greater in black than white borderline hypertensive patients. Arnett et al\textsuperscript{18} reported a greater incidence of LVH in black than white men in Evans County, Georgia. In the most recent study, Koren et al\textsuperscript{19} found that black relative to white subjects had greater LVM/BSA and a greater prevalence of LVH independent of other risk factors.

We found racial differences in the determinants of LVM adjusted for either height or BSA. For the black subjects, age was the most important determinant of either measure. Sex was also an independent determinant of both measures. In contrast, SBP was the most important determinant of LVM/height in black subjects, followed by $U_{Na}$V. The influence of sex approached significance. For LVM/BSA, sex was the most important determinant of LVM, while SBP was the only other independent determinant. The racial difference in the importance of age may help to explain differences in the results of the pediatric and adult studies. An examination of Fig 2 indicates that racial differences in LVM/height begin to appear by age 12 and increase with age. For example, the slopes relating age to LVM/height indicate that 12-year-old black subjects had an LVM/height that was only 1.54 g/m greater than for 12-year-old white subjects. However, the difference increased to 25 g/m by the age of 18. For LVM/BSA, 12-year-old white subjects had a slightly greater LVM/BSA of 0.4 g/m\textsuperscript{2}. However, by 18 years of age, the LVM/BSA of black subjects was 22 g/m\textsuperscript{2} greater. Extrapolation of these data suggests that racial differences would appear in adulthood.

Two other results of this study are worthy of note. The first concerns the percent of variance accounted for by the multiple-regression models. None of the models accounted for more than 43% of the variance of LVM adjusted for height or BSA, leaving the majority of the variance unaccounted for. However, the models accounted for more of the variance for black than for white subjects. Second, the results were very similar for LVM indexed by height and BSA.

In summary, sex, age, and SBP were independent determinants of LVM adjusted for body size in a sample of black and white youths. However, different models were found when the black and white subjects were considered separately. For black subjects, age was the most important factor, followed by sex. For white subjects, SBP was the most important factor, with $U_{Na}$V contributing to the model for LVM adjusted by height. The age-related increase in black but not white youths may help to explain the differences in the results of pediatric and adult studies. As such, they are consistent with the hypothesis that increased LVM contributes to the increased incidence and greater prevalence of cardiovascular disease that characterizes the black population.

Acknowledgments

This study was supported by National Institutes of Health grants HL-35788, USHPS T35 DK074050G, HL-46177, and GCRC M01-RR0021.

References


6. Koren MJ, Devereux RB, Casale PN, Savage DD, Laragh JH. Relation of left ventricular mass and geometry to morbidity in men and women with essential hypertension. Ann Intern Med. 1991;114: 345-352.


8. Frolich ED. Potential mechanisms explaining the risk of left ventricular hypertrophy. Am J Cardiol. 1987;59:91A-97A.


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*Hypertension*. 1994;24:747-751
doi: 10.1161/01.HYP.24.6.747

*Hypertension* is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
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Print ISSN: 0194-911X. Online ISSN: 1524-4563

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