Familial Aggregation of Arterial Blood Pressure and Possible Genetic Influence

Ayrton P. Brandão, Andréa A. Brandão, Eugênia M. Araújo, and Rita C. Oliveira

The aggregation of arterial blood pressure, weight, and height were compared between family members of children and adolescents with blood pressure percentiles at or above 95 (group 1) and at or below 50 (group 2). Weight, height, and systolic and diastolic blood pressures were significantly higher in siblings and target individuals of group 1 (p<0.001). Weight and systolic and diastolic blood pressures were significantly higher in mothers of group 1 (p<0.001). Covariant analysis comparing the average systolic and diastolic blood pressures of both groups controlled by age, age and weight, and age and Quetelet index revealed that the arterial blood pressure of mothers, siblings, and target individuals remained higher in group 1 (p<0.05 to p<0.001). These observations show a strong familial aggregation of arterial blood pressure not dependent only on physical development and also raise the question of a genetic basis as a possible mechanism of systemic arterial hypertension.

Hypertension is an important risk factor for cardiovascular disease morbidity and mortality in the industrialized world. No single cause for the elevation of blood pressure has been consistently identified. An increased familial prevalence of hypertension has been known for many years, suggesting an interaction between genetic susceptibility and environmental factors. Evidence that arterial hypertension in adults may be initiated at an early age has renewed interest in the study of blood pressure in children and adolescents. The main objectives of such studies are to establish normal blood pressure values for this population and to correlate these findings with age, sex, race, physical development, socioeconomic level, familial aggregation, and other factors.1-4

Familial aggregation of arterial blood pressure has been shown by many authors.5-7 Some studies have demonstrated that this aggregation can be explained on a genetic basis,8,9 whereas others have implicated environmental factors.10 Still others suggest the possibility of an interaction between both factors.11

The purpose of the present study was to investigate the familial aggregation of arterial blood pressure, weight, and height between parents and siblings of children with blood pressure percentiles at or below 50 (normal) and at or above 95 (abnormal).

Methods

First Stage

A total of 3,906 children were examined at public and private schools in Rio de Janeiro. The population was sampled by strata according to socioeconomic status (high, medium, and low), age (10-15 years of age), and gender, resulting in 36 strata with a minimum of 100 children in each. The classification of socioeconomic status in all schools was reported by the Secretary of Education for Rio de Janeiro according to the parents' profession and monthly income. Blood pressure was measured in the right arm with the subject in a supine position. A wall-mounted mercury-type sphygmomanometer was used in all cases, with cuff sizes of 7.5, 9.5, 12, and 14 cm in width and 36 and 53 cm in length. Diastolic blood pressure was determined at Korotkoff phase V. Three blood pressure measurements were obtained; the value of the last determination was used for the analysis. Examinations were performed between 7 AM and 5 PM without any preestablished time.

Second Stage

The aggregation of systolic and diastolic blood pressures, weight, and height were compared between the parents and siblings of two groups of surveyed children. Group 1 (298 individuals) was composed of parents (167 individuals) and siblings (131 individuals) of 106 children and adolescents taken from the total group who were at or above the 95th percentile for systolic or diastolic blood pressure or both (abnormal). Group 2 (285 individuals) was composed of parents (158 individuals) and siblings (127 individuals) of 100 children randomly selected

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Supported in part by grants from the National Council for Research and the Rio de Janeiro State Council for Research.

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TABLE 1. Weight and Height in Study Groups

<table>
<thead>
<tr>
<th>Population</th>
<th>Group</th>
<th>No. of cases</th>
<th>Weight (kg)</th>
<th>Average</th>
<th>SD</th>
<th>Height (cm)</th>
<th>Average</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Target individuals</td>
<td>1</td>
<td>106</td>
<td>58.25</td>
<td>13.95</td>
<td>162.88</td>
<td>10.96</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>100</td>
<td>46.12*</td>
<td>10.16</td>
<td>157.50†</td>
<td>9.82</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fathers</td>
<td>1</td>
<td>73</td>
<td>75.36</td>
<td>12.82</td>
<td>169.46</td>
<td>7.27</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>70</td>
<td>71.51†</td>
<td>15.79</td>
<td>168.97‡</td>
<td>11.99</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mothers</td>
<td>1</td>
<td>94</td>
<td>65.31</td>
<td>11.47</td>
<td>157.11</td>
<td>6.57</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>88</td>
<td>61.47§</td>
<td>10.15</td>
<td>157.25‡</td>
<td>6.86</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Siblings</td>
<td>1</td>
<td>131</td>
<td>53.97</td>
<td>18.70</td>
<td>157.60</td>
<td>17.85</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>127</td>
<td>45.58†</td>
<td>17.27</td>
<td>152.66§</td>
<td>18.06</td>
<td></td>
<td></td>
</tr>
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</table>

*p<0.001, †p<0.01, ‡not significant, §p<0.05.

Results

Tables 1 and 2 summarize the results for the differences between the two groups. There were no age differences between the children, parents, or siblings of both groups. By design, target individuals differed significantly in regard to systolic and diastolic blood pressures. Group 1 children were also significantly heavier and taller than those in group 2. Average systolic and diastolic blood pressures as well as weight and height did not differ significantly between the fathers of group 1 and group 2 children. In contrast, comparison of average systolic and diastolic blood pressures as well as weight revealed significantly higher values for group 1 as compared with group 2 mothers. The differences between siblings of both groups were also significant for systolic and diastolic blood pressures, as well as for weight and height. There were no sex difference values in regard to blood pressure, weight, and height when we compared target individuals and siblings of groups 1 and 2.

Analysis of covariance comparing the average arterial blood pressure measurements between the two groups adjusted for age, age and weight, and age and Quetelet index showed that the systolic and diastolic blood pressures of target individuals, siblings, and mothers of group 1 children remained higher than those of group 2 (Table 3).

Discussion

A familial tendency toward development of hypertension has been known for more than 30 years. Recent studies have suggested that several components of the blood pressure control system may be under genetic control. Familial aggregation of diastolic and systolic blood pressures has been described in several populations. In general, these studies can be explained on the basis of either genetic or environmental influences on blood pressure such as diet, excess weight, and emotional stress.

Feinleib et al showed a close correlation between systolic and diastolic blood pressures in monozygotic twins and other siblings. On the basis of these findings, the authors estimated that 82% of the variance in systolic blood pressure elevations and

TABLE 2. Systolic and Diastolic Blood Pressures in Study Groups

<table>
<thead>
<tr>
<th>Population</th>
<th>Group</th>
<th>No. of cases</th>
<th>Systolic blood pressure 2* (mm Hg)</th>
<th>Average</th>
<th>SD</th>
<th>Diastolic blood pressure 2* (mm Hg)</th>
<th>Average</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Target individuals</td>
<td>1</td>
<td>106</td>
<td>130.61</td>
<td>14.95</td>
<td></td>
<td>75.60</td>
<td>12.92</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>100</td>
<td>110.88†</td>
<td>11.42</td>
<td></td>
<td>62.22†</td>
<td>12.95</td>
<td></td>
</tr>
<tr>
<td>Fathers</td>
<td>1</td>
<td>73</td>
<td>139.00</td>
<td>21.91</td>
<td></td>
<td>88.89</td>
<td>13.71</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>70</td>
<td>135.88‡</td>
<td>18.31</td>
<td></td>
<td>85.62‡</td>
<td>12.82</td>
<td></td>
</tr>
<tr>
<td>Mothers</td>
<td>1</td>
<td>94</td>
<td>141.42</td>
<td>24.88</td>
<td></td>
<td>87.95</td>
<td>14.12</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>88</td>
<td>129.23§</td>
<td>23.88</td>
<td></td>
<td>82.01†</td>
<td>13.73</td>
<td></td>
</tr>
<tr>
<td>Siblings</td>
<td>1</td>
<td>131</td>
<td>121.77</td>
<td>15.00</td>
<td></td>
<td>74.74</td>
<td>14.60</td>
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</tr>
<tr>
<td></td>
<td>2</td>
<td>127</td>
<td>113.13§</td>
<td>15.15</td>
<td></td>
<td>65.76†</td>
<td>13.61</td>
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</tbody>
</table>

*p<0.001, †p<0.01, ‡not significant, §p<0.05.
64% of diastolic variance could be of genetic origin. In addition, identification of a genetic basis for blood pressure has been suggested by comparisons within monozygotic and dizygotic twin pairs, studies of monozygotic twins and unrelated individuals, and studies of monozygotic twins who were adopted into different households soon after birth. Observations from these studies document a genetic familial relation for blood pressure and confirm the earlier impression that this relation is based on heritable factors. Body weight appears to be distinctly related to arterial hypertension, which could be related to a genetic influence and an increased ingestion of salt. The greater ingestion of food in physically more developed subjects raises the possibility of an increased ingestion of salt. Populations with a lesser salt intake show a lower prevalence of arterial hypertension. Clinical observation suggests that a reduction in dietary salt intake may reduce blood pressure in hypertensive individuals, although remain doubtful about the usefulness of this approach. Epidemiological studies show a greater prevalence of hypertension in populations with higher dietary sodium intake. On the other hand, some of the differences in weight and especially height could reflect metabolic factors involving growth hormone and insulin. Insulin hormone acting directly or indirectly through the stimulation of growth factors such as insulin-like growth factor I may contribute to the development of hypertension by causing vascular hypertrophy with narrowing of the luminal diameter of resistance vessels involved in blood pressure regulation. Consistent with this, receptors for insulin and insulin-like growth factor I have been found in such vessels.

A familial aggregation of blood pressure, weight, and height was clearly demonstrated in the present study. Covariant analysis by controlling for age, age and weight, and age and Quetelet index revealed that the blood pressure, systolic and diastolic, of mothers, siblings, and target individuals in group 1 (abnormal) remained higher than those of group 2 (normal) (p<0.05 to p<0.0001). These observations show a strong familial aggregation of arterial blood pressure not dependent only on physical development. They raise the possibility that genetic factors also could be an important etiologic factor in the genesis of arterial hypertension.

These observations show the importance of long-term follow-up of children and adolescents and other family members in an attempt to correlate childhood and adult levels of blood pressure. This eventually could establish a basis for primary prevention of arterial hypertension.

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**Key Words** • children • adolescents • blood pressure • genetics • family • body mass index
Familial aggregation of arterial blood pressure and possible genetic influence.
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Hypertension. 1992;19:I214
doi: 10.1161/01.HYP.19.2_Suppl.I214

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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