Quantification of Blood Pressure Tracking of Children by Tracking Index: The Shimane Heart Study

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The tracking of systolic blood pressure (SBP) was analyzed in a cohort of children. The study population consisted of 1009 Japanese children in Izumo City, a rural community in the northwest of Honshu. There were 252 subjects in cohort (C)1, 235 in C-2, 286 in C-3, 131 in C-4 and 105 in C-5. Follow-up periods were from 6 to 9 years of age in C-1, 9 to 12 in C-2, 12 to 15 in C-3, 6 to 12 in C-4 and 9 to 15 in C-5. BP was measured by conventional method. Tracking index (TI) was calculated as follows: \( TI = \frac{(2x + y - z)}{N/24}; \) x, y and z are numbers of subjects who remained at the same quintile, who moved to the next quintile and who moved to a remote quintile, respectively; \( N = x + y + z; \) TI becomes 1.0 when SBP changes randomly. SBP tracking was apparent in both sexes of C-1 (TI = 2.4 in boys, 2.5 in girls), in girls of C-2 (TI = 3.5), in both sexes of C-3 (TI = 3.2 in boys, 2.7 in girls) and in girls of C-4 (TI = 4.1) and C-5 (TI = 3.3). TI agreed well with the tracking phenomena visualized by distribution bar graph. We conclude that TI can assess the degree of tracking quantitatively and can be applied to analysis of the tracking phenomena of BP and its related factors.

For the primary prevention of hypertension, it is very important to investigate blood pressure (BP) prospectively from childhood. For this purpose, we initiated the longitudinal study named the Shimane Heart Study in 1978. The cohorts of children were examined every 3 years to obtain data on the tracking of BP during childhood.

Tracking means the maintenance of the relative ranking of an individual with respect to his peers. If there is tracking, the BP of children with a high percentile ranking at the first examination will remain high at the following examinations. This report is concerned with the analysis of tracking of BP during childhood, and the trial to assess the degree of tracking quantitatively.

MATERIALS AND METHODS

Subjects
The study population consisted of 1009 Japanese children in Izumo City, a rural community with a population of about 80,000 located in the northwest of Honshu, the main island of Japan. All elementary and junior high school children were enrolled in the Shimane Heart Study. Table I shows the number of subjects in each cohort. Cohorts 1, 2 and 3 were

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TABLE I

<table>
<thead>
<tr>
<th>Cohort</th>
<th>Examination</th>
<th>No. of subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1st</td>
<td>2nd</td>
</tr>
<tr>
<td>1</td>
<td>6 → 9 yrs</td>
<td>118</td>
</tr>
<tr>
<td>2</td>
<td>9 → 12 yrs</td>
<td>122</td>
</tr>
<tr>
<td>3</td>
<td>12 → 15 yrs</td>
<td>141</td>
</tr>
<tr>
<td>4</td>
<td>6 → 12 yrs</td>
<td>83</td>
</tr>
<tr>
<td>5</td>
<td>9 → 15 yrs</td>
<td>56</td>
</tr>
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</table>

Followed for 3 years from 6, 9 and 12 years of age, respectively. Cohorts 4 and 5 were observed for 6 years from 6 and 9 years of age, respectively.

**Measurements**

The BP was measured in the sitting position in the right arm after 5 minutes' rest by mercury sphygmomanometer and bell type stethoscope (Littmann Pediatric size). Cuff size was 9 and 12 cm for children of 8 years or less and 9 years or more, respectively. Diastolic pressure was read at the 4th Korotkoff phase. Two measurements were performed in one examination and the lower systolic value was defined as the BP of individual children.

The observers were trained by video tape edited by Prof. D.R. Labarthe of the School of Public Health, the University of Texas Health Science Center at Houston, USA. The examinations were performed in late spring and early fall when the temperatures were moderate in Izumo City.

**Calculation of tracking index**

In order to clarify the BP tracking, the subjects were divided into 5 groups by their systolic blood pressure (SBP) at the first examination. Group A consisted of children whose SBP belonged to the lowest quintile ranking, i.e., less than 20 percentile in their peers. Similarly, group E belonged to the highest quintile, that is, more than 80th percentile. The same subjects were divided again into 5 quintile groups by the

Fig.1. Classification of tracking by SBP quintile at 1st and 2nd examinations.
SBP of the second examination performed 3 or 6 years later.

The tracking index (TI) was calculated by the following formula, where the symbols x, y and z indicate the number of subjects in groups X, Y and Z, respectively, as shown in Fig. 1. N was the sum of x, y and z.

\[ T = \frac{2x + y - z}{N} \]

\[ TI = \frac{T(s)}{T(h)} = \frac{2x + y - z}{N/0.24} \]

T(s) was the calculated T of the study cohort.
T(h) was the T of the hypothetical cohort without tracking, SBP of which is distributed.
TABLE II  TRACKING INDEX OF SBP IN EACH COHORT

<table>
<thead>
<tr>
<th>Cohort</th>
<th>Examination</th>
<th>Tracking index</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1st</td>
<td>2nd</td>
</tr>
<tr>
<td>1</td>
<td>6 → 9 yrs</td>
<td>2.4</td>
</tr>
<tr>
<td>2</td>
<td>9 → 12 yrs</td>
<td>1.7</td>
</tr>
<tr>
<td>3</td>
<td>12 → 15 yrs</td>
<td>3.2</td>
</tr>
<tr>
<td>4</td>
<td>6 → 12 yrs</td>
<td>1.3</td>
</tr>
<tr>
<td>5</td>
<td>9 → 15 yrs</td>
<td>1.1</td>
</tr>
</tbody>
</table>

TABLE III  CORRELATION COEFFICIENTS (r) OF SBP BETWEEN 1ST AND 2ND EXAMINATIONS

<table>
<thead>
<tr>
<th>Cohort</th>
<th>Examination</th>
<th>r</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1st</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2nd</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>6 → 9 yrs</td>
<td>0.34</td>
</tr>
<tr>
<td>2</td>
<td>9 → 12 yrs</td>
<td>0.26</td>
</tr>
<tr>
<td>3</td>
<td>12 → 15 yrs</td>
<td>0.54</td>
</tr>
<tr>
<td>4</td>
<td>6 → 12 yrs</td>
<td>0.11</td>
</tr>
<tr>
<td>5</td>
<td>9 → 15 yrs</td>
<td>0.29</td>
</tr>
</tbody>
</table>

randomly and equally in all squares of Fig. 1. Therefore, T(h) was constantly 0.24. TI was defined as T(s) corrected by T(h). The index becomes 1.0 when there is no tracking in SBP of the cohort. On the other hand, TI becomes higher according to the increase in degree of tracking.

RESULTS

SBP tracking in each cohort

Tracking of SBP was apparent in both sexes of every cohort as shown in Figs. 2 and 3. Details of the data were described in a previous report.

Tracking indices

SBP tracking indices of each cohort are shown in Table II. For the cohorts followed for 3 years, the indices were high for both sexes of cohorts 1 and 3. In cohort 2, the index was high in girls, but low in boys. As for cohorts 4 and 5 followed for 6 years, the indices were high in girls and very low in boys. These figures agreed well with the impression obtained by visualization of tracking in Figs. 2 and 3.

Correlation coefficients between SBP of 1st and 2nd examinations

As shown in Table III, the trends of the correlation coefficients in each cohort were similar to those of the tracking indices describes above.

DISCUSSION

During childhood and adolescence, BP and various anthropometric measurements are said to track with age. A similar tendency is reported in adults. Therefore, BP in childhood seems to have predictive values for the subsequent BP status in adulthood.

In the study of blood pressure tracking, quintile ranking is usually compared between an initial and a subsequent examinations as shown in Figs. 2 and 3. Although the tracking can be assessed intuitively and qualitatively using such a method, it is impossible to quantitate the degree of tracking.

Quantification is very important for the study of BP tracking in childhood. For this purpose, we devised a formula to calculate the degree of tracking. Subjects were divided into 3 groups (X, Y and Z) as shown in Fig. 1. The change of their SBP quintile during the observation period was used as the criteria for classification. According to the degree of tracking, the weighting factors 2, 1 and -1 were given for subjects belonging to group X, Y and Z, respectively.

The tracking index calculated by the above-
mentioned tendency observed in the distribution bar graph as shown in Figs. 2 and 3. We conclude that the tracking index can assess the degree of tracking quantitatively and can be applied to analysis of the tracking phenomena of BP and its related factors during childhood.

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