Changes in Cardiovascular Risk Factors over a 24-Year Follow-Up Period: A Japanese Pediatric Cohort Study

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ABSTRACT

This study examined changes in body mass index (BMI), fasting blood sugar (FBS), total cholesterol (TC) and HDL-cholesterol (HDL-C) levels over a 24-year follow-up period in a pediatric cohort. An appropriate starting age for intervention to prevent cardiovascular diseases is still unclear. The subjects were 655 children, aged 10-12. A follow-up survey was conducted when the subjects reached ages 13-15, 16-18, and 35-45, respectively, and height, weight, and blood tests including FBS, TC and HDL-C were examined. Forty (6%) of these subjects participated. BMI at ages 35-45 were significantly higher than those at ages 10-12 (p < 0.0001), 13-15 (p < 0.001), and 16-18 (p < 0.001). TC levels at ages 35-45 were significantly higher than at ages 10-12 (p < 0.0001), 13-15 (p < 0.0001), and 16-18 (p < 0.0001). BMI at the end of the follow-up (ages 35-45) had a significant correlation with BMI at ages 13-15 (R = 0.38, p = 0.041) and 16-18 (R = 0.41, p = 0.049). TC and HDL-C values at the end of the follow-up had a significant correlation with those at ages 10-12 (R = 0.55, p = 0.0004; R = 0.55, p = 0.016), 13-15 (R = 0.35, p = 0.045; R = 0.42, p = 0.015), and 16-18 (R = 0.47, p = 0.019; R = 0.44, p = 0.028). These results may suggest that intervention for children in Japan with cardiovascular risk factors should be initiated in the early years of life.

Key words: Asa Cohort Study, Cardiovascular risk factor, Follow-up study, BMI

Epidemiological studies have demonstrated that the atherosclerotic process begins in childhood and that individual cardiovascular risk factors, such as obesity, hypertension, hyperglycemia, and dyslipidemia, tend to persist over time from childhood to adulthood¹,². For example, in the case of obesity, although Whitaker et al¹⁵) reported that the risk of childhood obesity progressing to adult obesity rises markedly after the age of 10, there are no clear answers to questions such as when intervention should be initiated to prevent cardiovascular diseases. To answer these questions, it is necessary to understand the tracking tendency of cardiovascular risk factors. However, there are few reports on such factors, especially in Japanese children.

In the present study, therefore, we focused on the correlation in changes in body mass index (BMI), levels of fasting blood sugar (FBS), total cholesterol (TC) and HDL-cholesterol (HDL-C) over a 24-year follow-up period in a Japanese pediatric cohort.

MATERIALS AND METHODS

Study population

This study was conducted as part of a pediatric health promotion program--“Asa Cohort study”--initiated in 1978 in Asa, Hiroshima, Japan⁷,⁸. In addition to health checkups of elementary school students performed in accordance with the Japanese School Health Act (School Health and Safety Act, amended in 2008), Asa has a unique health-promotion program in place. Those who

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volunteered to take part in the program underwent blood and physical examinations.

The subjects were elementary school students aged 10-12 who agreed to participate in the study. A total of 1,407 students took part in the study's initial survey.

Examinations
A follow-up survey was conducted when the subjects reached ages 13-15 (junior high school), 16-18 (high school), and 35-45 (adults). At the time of the initial and follow-up surveys, the subjects underwent physical measurements including height and weight, and blood tests including FBS, TC and HDL-C. BMI was used as an index for obesity status. Only those who had reached the age of 35-45 by the end of the 24-year follow-up period, and who had taken part in the follow-up examinations, were included in the present study.

Statistical analysis
The ratio of the follow-up values compared to the baseline data (ages 10-12), and data at ages 13-15 and 16-18, were examined for each test variable. A paired t-test and Spearman's correlation coefficient were used to evaluate any correlation between these values. Statistical analyses were made using JMP software (SAS Institute, Cary, NC, USA). p < 0.05 was settled as statistically significant.

Ethics
Informed consent was obtained from the subjects and their parents. This study was approved by the Ethics Committee of the Hiroshima Asa Medical Association.

RESULTS
Follow-up
The number of subjects who would reach the age of 35-45 by the end of the follow-up period was 655 (male/female: 301/354). Forty (6%) of these subjects participated in the examinations during the 24-year follow-up period. Relocation was the major reason that children were lost from follow-up. There were no statistical differences in baseline values between those available for follow-up and those lost from follow-up for factors including BMI, FBS, TC, and HDL-C (Table 1).

Table 2 shows values measured for each age group. BMI increased gradually as age increased. BMI at ages 35-45 was significantly higher than at ages 10-12 (p < 0.0001), 13-15 (p < 0.001), and 16-18 (p < 0.001), respectively. TC also increased gradually as age increased. TC at ages 35-45 was significantly higher than at ages 10-12 (p < 0.0001), 13-15 (p < 0.0001), and 16-18 (p < 0.0001), respectively. On the other hand, FBS and HDL-C showed no significant changes across the age groups.

Table 1. BMI, FBS, TC, and HDL-C in follow-up and control groups (mean ± standard deviation)

<table>
<thead>
<tr>
<th></th>
<th>Follow-up group (n=40)</th>
<th>Control group (n=615)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMI (kg/m²)</td>
<td>17.4 ± 2.9</td>
<td>17.9 ± 2.8</td>
<td>0.275</td>
</tr>
<tr>
<td>FBS (mg/dl)</td>
<td>91.2 ± 7.3</td>
<td>92.4 ± 10.3</td>
<td>0.469</td>
</tr>
<tr>
<td>TC (mg/dl)</td>
<td>172.7 ± 31.7</td>
<td>178.7 ± 29.5</td>
<td>0.215</td>
</tr>
<tr>
<td>HDL-C (mg/dl)</td>
<td>61.5 ± 11.4</td>
<td>62.7 ± 15.6</td>
<td>0.633</td>
</tr>
</tbody>
</table>

BMI: body mass index, FBS: fasting blood sugar, TC: total cholesterol, HDL-C: HDL-cholesterol.

Correlation analysis
BMI at the end of the follow-up (ages 35-45) significantly correlated with BMI at ages 13-15 (R = 0.38, p = 0.041) and 16-18 (R = 0.41, p =0.049) (Fig. 1). BMI at ages 35-45, however, had no significant correlation with BMI at ages 10-12 (R = 0.34, p = 0.15).

TC and HDL-C levels at the end of the follow-up had a significant correlation with those at ages10-12 (R = 0.55, p = 0.0004; R = 0.55, p = 0.016), 13-15 (R = 0.35, p = 0.045; R = 0.42, p = 0.015), 16-18 (R = 0.47, p = 0.019; R = 0.44, p = 0.028), respectively (Fig. 2, 3).

The FBS level at the end of the follow-up was not significantly correlated with the levels observed at ages 10-12 (R = 0.18, p = 0.28), 13-15 (R = 0.31, p = 0.077) or 16-18 (R = 0.18, p = 0.39) (Fig. 4).

Table 2. Values measured at ages 10-12, 13-15, 16-18, and 35-45 (mean ± standard deviation)

<table>
<thead>
<tr>
<th>Ages</th>
<th>10-12</th>
<th>13-15</th>
<th>16-18</th>
<th>35-45</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMI (kg/m²)</td>
<td>17.4 ± 2.9*</td>
<td>20.1 ± 3.0**</td>
<td>20.6 ± 2.0**</td>
<td>22.9 ± 3.4</td>
</tr>
<tr>
<td>FBS (mg/dl)</td>
<td>91.2 ± 7.3</td>
<td>94.4 ± 6.6</td>
<td>92.7 ± 14.2</td>
<td>94.5 ± 24.8</td>
</tr>
<tr>
<td>TC (mg/dl)</td>
<td>172.7 ± 31.7*</td>
<td>178.3 ± 28.4**</td>
<td>170.3 ± 21.8*</td>
<td>207.8 ± 35.3</td>
</tr>
<tr>
<td>HDL-C (mg/dl)</td>
<td>61.5 ± 11.4</td>
<td>60.5 ± 17.8</td>
<td>63.0 ± 12.9</td>
<td>61.7 ± 16.3</td>
</tr>
</tbody>
</table>

BMI: body mass index, FBS: fasting blood sugar, TC: total cholesterol, HDL-C: HDL-cholesterol.

*p < 0.0001 compared with ages 35-45 by paired t-test
**p < 0.001 compared with ages 35-45 by paired t-test
**Fig. 1.** Correlation of body mass index (BMI) between ages 35-45 and ages 10-12, 13-15, and 16-18.

**Fig. 2.** Correlation of total cholesterol (TC) between ages 35-45 and ages 10-12, 13-15, and 16-18.

**Fig. 3.** Correlation of HDL-cholesterol (HDL-C) between ages 35-45 and ages 10-12, 13-15, and 16-18.

**Fig. 4.** Correlation of fasting blood sugar (FBS) between ages 35-45 and ages 10-12, 13-15, and 16-18.
DISCUSSION

In the present study, we demonstrated that TC and HDL-C levels in adulthood have moderate correlations with those in childhood and adolescence, and that BMIs in adulthood and adolescence are moderately correlated. These results may suggest that health education should be provided during childhood, and that intervention in Japanese children with cardiovascular risk factors should be initiated early on in life.

There are several reports in pediatric cohort studies from western countries on changes in cardiovascular risk factors. For example, the Bogalusa Heart Study\(^1\) showed that the correlation coefficients over 12 years were 0.42-0.66 for TC and 0.29-0.43 for HDL-C; and over 15 years they were 0.43-0.74 for BMI, 0.35-0.69 for TC, 0.17-0.61 for HDL-C, 0.38-0.43 for systolic BP, and 0.21-0.29 for diastolic BP. The Young Finns Study\(^2\) reported that correlation coefficients over 6 years were 0.65-0.73 for TC and 0.66-0.76 for HDL-C; and over 12 years, they were 0.48-0.58 for TC and 0.53-0.58 for HDL-C. Laskarzewski et al\(^3\) reported that the correlation coefficients over 4 years were 0.68 for TC and 0.53 for HDL-C. On the other hand, only one pediatric cohort study on this issue was conducted in Japan. The study by Tan et al\(^4\) demonstrated that correlation coefficients over 4 years were 0.62 for TC, and 0.66 for HDL-C. In our study, correlation coefficients over 24 years were 0.55 for both TC and HDL-C. Although the observation period in our study was longer compared with previous studies, the values were similar to those in previous reports. TC and HDL-C levels in adulthood may be moderately correlated. The results of this Asa Cohort Study may suggest the importance of programs aimed at reducing cardiovascular risk factors in Japanese children. Further studies are needed to clarify what intervention methods would be useful in preventing cardiovascular risk factors in Japanese school children.

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REFERENCES

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