Temporal Trends in Atherosclerotic Risk Factors in School Children — Findings From 20-Year Surveillance —

Daisuke Sueta, MD, PhD; Eiichiro Yamamoto, MD, PhD; Miyuki Sato; Takahiko Sato, MD; Koichiro Fujisue, MD, PhD; Yuichiro Arima, MD, PhD; Seiji Takashio, MD, PhD; Kenji Sakamoto, MD, PhD; Hirofumi Soejima, MD, PhD; Koichi Kaikita, MD, PhD; Nobuyuki Shigaki, MD, PhD; Yasuhiro Takasu; Kenichi Tsujita, MD, PhD

Background: Although it has been discussed which measures against atherosclerotic diseases should be started in childhood, the current situation in Japan is unclear.

Methods and Results: We conducted a health management survey of all 12-year-old children in a local town for 20 years. The body mass index tended to decrease over time. Although the serum low-density lipoprotein cholesterol level did not change, the levels of serum high-density lipoprotein cholesterol and serum triglycerides significantly increased over time.

Conclusions: The serum triglyceride levels in school children increased significantly, probably through lifestyle changes, and the health management system should be reviewed.

Key Words: Atherosclerosis; Lipid management; Risk factor; School children

Atherosclerotic lesions, including ischemic heart disease (IHD), are predicted by the presence in childhood of risk factors for early-stage lesions.1–3 Accumulating clinical evidence has also shown that cardiovascular risk reduction can delay the onset of atherosclerosis and change its course and that the primary prevention of coronary artery disease should begin in childhood.3–5 Furthermore, atherosclerotic diseases such as IHD develop and progress in part because of lifestyle habits. Although the necessity of implementing intensive and fundamental preventive measures in childhood has been debated in recent years, the current situation is unclear. We conducted a prospective health management survey of all 12-year-old children in a local town annually for 20 years starting in 2000. This study was a community-based, prospective, registry study conducted in Nagomi Town, which is located in the northern region of Kumamoto Prefecture in the center of Kyushu Island, Japan. It is a peaceful garden town with a total population of approximately 10,000 people (3,500 families). We registered all 12-year-old children in Nagomi Town starting in 2000. We enrolled 1,424 children at 5 elementary schools with complete data, including body height, body weight, blood pressure, and levels of serum low-density lipoprotein cholesterol (LDL-C), serum high-density lipoprotein cholesterol (HDL-C), and serum triglycerides (TG). All blood samples were collected under fasting conditions. All surveys were conducted annually in August. We classified all subjects into 3 categories according to the enrollment period: from 2000 to 2005 was defined as P1 (200 females and 211 males: total 411), from 2006 to 2012 as P2 (307 females and 298 males: total 605), and from 2013 to 2019 as P3 (201 females and 207 males: total 408). All procedures were conducted in accordance with the Declaration of Helsinki and its amendments. The study protocol was approved by the institutional review board of Kumamoto University (approval no. Rinri 1686). A P-value <0.05 was considered statistically significant.

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Department of Cardiovascular Medicine and Center for Metabolic Regulation of Healthy Aging, Graduate School of Medical Sciences, Kumamoto University, Kumamoto (D.S., E.Y., K.F., Y.A., S.T., K.S., H.S., K.K., K.T.); Health and Welfare Division, Nagomi Town Office, Kumamoto (M.S.); Nagomi Town Hospital, Kumamoto (T.S., N.S.); and Mayor of Nagomi Town, Kumamoto (Y.T.) Japan
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Mailing address: Daisuke Sueta, MD, PhD, Department of Cardiovascular Medicine, Graduate School of Medical Sciences, Kumamoto University, 1-1-1 Honjo, Chuo-ku, Kumamoto 860-8556, Japan. E-mail: sueta-d@kumamoto-u.ac.jp
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Figure 1. Cross-sectional changes in the characteristics of elementary school children (female). Summary data of each parameter as a scatter plot. Purple lines indicate the mean ± standard deviation values. The numbers outside the plots indicate mean values. P1, P2 and P3 indicate Period 1 (2000–2005), Period 2 (2006–2012), and Period 3 (2013–2019), respectively. Statistical analysis was performed by 1-way ANOVA followed by Bonferroni’s post hoc test. *P<0.05 vs. P1; **P<0.01 vs. P1; †P<0.05 vs. P2; ‡P<0.01 vs. P2. BMI, body mass index; BP, blood pressure; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; TG, triglycerides.
Figure 2. Cross-sectional changes in the characteristics of elementary school children (male). Abbreviations and symbols as in Figure 1.
As shown in Figure 1A and Figure 2A, body height did not change for either males or females. Body weight (Figure 1B,C) tended to decrease over time, and body mass index (BMI) (Figures 1D,2D) and the Röhrer index (Figures 1D,2D) significantly decreased over time. Systolic (Figures 1E,2E) and diastolic (Figures 1F,2F) blood pressure (BP) increased significantly in P2 compared with P1, and decreased significantly in P3 compared with P2. Although the serum LDL-C level (Figures 1I,2I) did not change, the serum HDL-C level (Figures 1H,2H) and serum TG level (Figures 1G,2G) significantly increased over time. The TG/HDL-C ratio (Figures 1J,2J), which is a recognized marker of insulin resistance and has been reported to be useful in predicting coronary events, significantly increased over time.

The main findings were as follows: first, BMI and BP significantly decreased over time, while the serum HDL-C level significantly increased over time; and second, serum TG level and, thus, the TG/HDL-C ratio significantly increased over time.

The upward trend in HDL-C level is consistent with the results of longitudinal studies of adults in Japan and the USA and is consistent with the trends in serum HDL-C level among US youths aged 6–19 years. In other words, the rural town showed the same trend as the global trend. The tendency of BMI to decrease is also a good trend for improving the health of school children. These trends are the result of ongoing efforts conducted by public health nurses and health teachers. In fact, according to the results of the questionnaire survey conducted simultaneously with the health survey, the number of school children who did not exercise regularly was also on the decline (Figure 3). Moreover, because BP levels tended to increase during P2, we ran a cooking practice session with parents and children and reviewed the school lunch menu. As a result, we believe, the BP levels decreased during P3. This is an example of appropriate interventions leading to improved risk factors.

However, the upward trend in the serum TG level is not consistent with the results of longitudinal studies of adults in Japan and is not consistent with the trends in serum HDL-C level among US youths aged 6–19 years. Our results show the latest trends in serum lipid levels among Japanese 12-year-olds. The mechanisms underlying the increase in serum TG levels and the discrepancy with adults and global trends are unknown, but we speculate the following.

Supplementary Figure shows the fish and meat intake and the fish/meat ratio of 7–14-year-old Japanese in the years 2000–2017. The meat intake increased and the fish intake decreased. Moreover, the fish/meat ratio in the Food and Agriculture Organization of the United Nations Statistics (FAOSTAT) data decreased from 0.99 kcal/capital/day in 2003–2005 to 0.77 kcal/capital/day in 2009–2011 while the ratio in other countries, including the USA, stayed the same or slightly increased. Furthermore, since the opening of the first convenience store (open 24 h) in 2006, the serum TG levels have gradually increased; currently, 4 stores are open. The surveillance was performed in August, and ice cream bought at convenience stores during the summer vacation may have had an impact. These trends are despite the continuous efforts of public health nurses and health teachers; hence, it remains necessary to carefully review the contents of the children’s diets, as the lipid profile, especially the level of TG, has tended to worsen.

In the present study, we demonstrated 2 aspects of the atherosclerotic risk factors in school children: a good one and a bad one. The good aspect includes that BMI, BP,
serum LDL-C, and serum HDL-C are well controlled, likely as the result of continuous efforts by parents, teachers and public health nurses. The bad aspect includes the increasing trend of serum TG levels, thought to be caused by lifestyle changes towards an increase in calorie intake despite apparent increases in exercise. Hence, it is necessary to review the health management system, including food education. Components (elements and items) of school lunches are shown in Supplementary Table. As for the contents of lunches, there is a tendency for the total calories to be reduced, the amount of meat is reduced, and the amount of fish (fish and small fish) is increased. However, school lunches make up one-sixth of the child’s total meals per year; thus, it is still up to the family to effect changes in diet. Therefore, we believe that food education that includes parents is very important. The speculated action of temporal trends in atherosclerotic risk factors in school children is demonstrated in Figure 4.

The present study has several limitations. First, in this observational study, the sample size was relatively small. Second, the study was performed in a specific population in a rural area. Thus, it would be enlightening to identify the extent to which the community under study is representative of other communities or indeed of Japan as a whole. Third, we did not measure waist circumference, serum non-HDL-C concentration, blood sugar level or hemoglobin A1c level. Fourth, the results of the questionnaire may not reflect the actual situation. Fifth, we did not examine how the results obtained in this observational study affected the results obtained in this observational study. Furthermore, data on obesity and metabolic syndrome in childhood and puberty are insufficient. It is necessary to prepare data-driven guidelines for primary and secondary prevention of obesity in childhood and puberty.

Despite these limitations, we have clearly demonstrated, for the first time, temporal trends in atherosclerotic risk factors in 12-year-old Japanese children. On the basis of this information, educational interventions are urgently needed. Our results can provide insight for lipid management interventions for children.

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**Disclosure of Conflicts of Interest**

K.K., K.T. are members of Circulation Journal’s Editorial Team. The other authors declare no conflicts of interest.

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**Supplementary Files**

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