Trends in cardiovascular risk factor levels in Finnish children and young adults from the 1970s: The Cardiovascular Risk in Young Finns Study

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OBJECTIVES: The Cardiovascular Risk in Young Finns Study is an ongoing multicentre study of atherosclerosis precursors in Finnish children and young adults. The aim of the present report is to describe the secular trends in cardiovascular risk factors between 1980 and 2001 in children and young adults.

METHODS: Data on cardiovascular risk factors were collected in a cohort of subjects (original n=3596) that were followed with serial cross-sectional studies from childhood to adulthood. The study was initiated in 1980, and the latest follow-up (after 21 years) was performed in 2001 (with n=2285 participants). To assess secular trends up to the year 2001, selected risk variables were analyzed (ie, total cholesterol, low density lipoprotein [LDL] cholesterol, high density lipoprotein [HDL] cholesterol, triglycerides, apolipoproteins A1 and B, blood pressure, body mass index [BMI] and daily intake of energy and quality of fat) in subjects with complete data for the years 1980, 1986 and 2001 (n=1758).

RESULTS: From 1980 to 1986, LDL-cholesterol concentrations decreased 0.32 mmol/L (P<0.0001) in subjects aged 15 to 18 years. From 1986 to 2001, LDL concentrations did not change in 24-year-old subjects (delta=–0.12 mmol/L, P>0.05). HDL-cholesterol concentrations decreased 0.28 mmol/L (P<0.0001) from 1986 to 2001. Triglyceride concentrations increased 0.21 mmol/L (P<0.0001) from 1980 to 1986 and 0.26 mmol/L (P<0.0001) from 1986 to 2001. In female subjects, BMI increased both from 1980 to 1986 (delta=0.5 kg/m^2, P=0.03) and from 1986 to 2001 (delta=1.7 kg/m^2, P=0.0002). Systolic blood pressure levels decreased 3.7 mmHg (P<0.0001) from 1980 to 1986 and 7.0 mmHg (P<0.0001) from 1986 to 2001 in all subjects.

CONCLUSION: The authors conclude that between 1986 and 2001, the decreases in LDL-cholesterol concentrations among young adults in Finland stopped. During the same time, HDL-cholesterol concentrations started to decrease, and triglyceride concentrations continued to decrease, and in female subjects, BMI continued to increase. However, also during this time, blood pressure levels continued to decrease in all subjects.

Key Words: *Blood pressure; Cardiovascular; Cholesterol; Obesity; Risk factors; Secular trend*

Although the major clinical complications of atherosclerosis, such as myocardial infarction and stroke, usually occur in middle and late age, it has been long recognized that the atherogenic process begins in childhood (1). The incidence of coronary artery disease (CAD) was very high in Finland from the 1960s through to the 1980s (2,3). The Seven Countries Study (4), published in 1966, showed that serum cholesterol concentrations were highest in Finland in the 1960s. At that time, Finnish children aged five to 13 years living in rural areas had a mean total cholesterol concentration greater than 6 mmol/L (5). In a study in the late 1970s, cholesterol concentrations in Finnish boys were the highest in an international survey (6). For these reasons and in accordance with the World Health Organization recommendation of 1978 (7), a program was launched in Finland in the late 1970s to study cardiovascular risk in the youth.

The Cardiovascular Risk in Young Finns Study was designed as a collaborative effort of all university departments of pediatrics (in Helsinki, Kuopio, Oulu, Tampere and Turku) and several other institutions in Finland to study the risk factors of cardiovascular diseases and their determinants in children and adolescents of various ages in different parts of the country. Two pilot studies were carried out in 1978 and 1979 (8,9). The first cross-sectional study was performed in 1980, and included 3596 children and adolescents aged three, six, nine, 12, 15 and 18 years (10). Between 1980 and 1992, these cohorts were followed-up in three-year intervals. The latest examination of the Cardiovascular Risk in Young Finns Study was performed in 2001, when the participants were young adults aged 24 to 39 years. The main objective of the Young Finns Study is to obtain data on the risk factors of CAD and to gather information for primary prevention. In the present report, we focus on examining the secular trends in risk factors.

METHODS

Population

The Cardiovascular Risk in Young Finns Study is an ongoing epidemiological study of atherosclerosis risk factors and precursors from childhood to adulthood. Data on cardiovascular risk factors were collected in a cohort of subjects (original n=3596) aged three, six, nine, 12, 15 and 18 years at baseline who were followed with serial cross-sectional studies from childhood to adulthood. The study was initiated in 1980, and the latest follow-up (after 21 years) was performed in 2001 (with n=2285 participants). To assess secular trends up to the year 2001, selected risk variables were analyzed in subjects with complete data for the years 1980, 1986 and 2001 (n=1758). The study was approved by local ethics committees. Details of the study design have been presented elsewhere (10).

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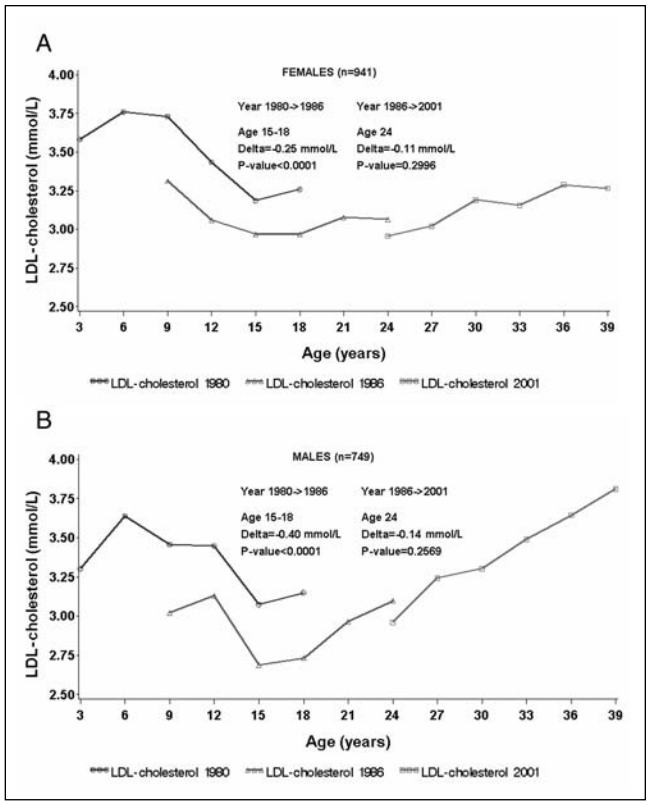

Figure 1) *Serum low density lipoprotein (LDL) cholesterol in female (***A***) and male (***B***) Finns aged three to 39 years in 1980, 1986 and 2001*

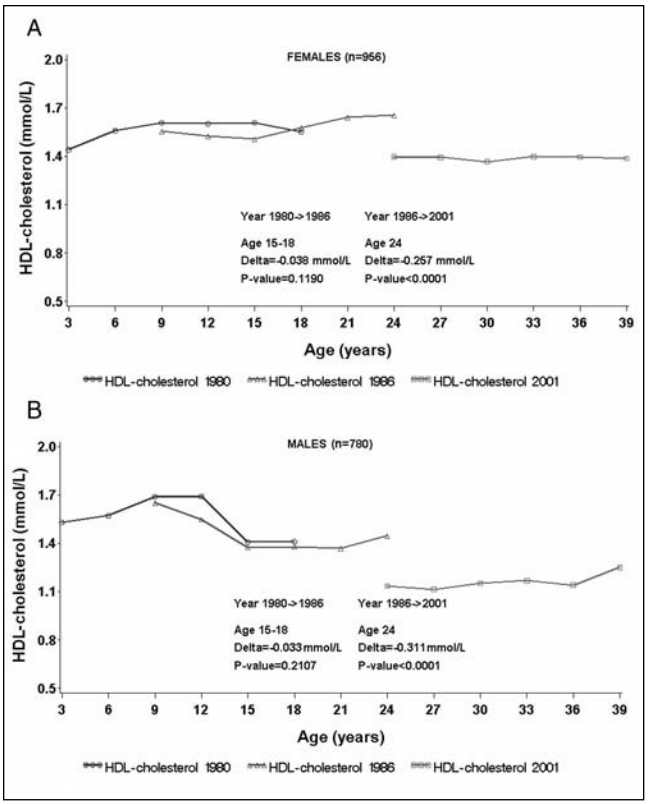

Figure 2) *Serum high density lipoprotein (HDL) cholesterol in female (***A***) and male (***B***) Finns aged three to 39 years in 1980, 1986 and 2001*

Risk factors

Weight was measured using a digital scale with an accuracy of 0.1 kg while subjects were in light clothes and without shoes. Height was measured using a wall-mounted stadiometer with an accuracy of 0.5 cm. Body mass index (BMI) was calculated by dividing the weight in kilograms by the square of the height in metres. In 1980, blood pressure was measured in three-year-old children using an ultrasound device (Arteriosonde 1020, Roche, Switzerland) and in others using a standard mercury sphygmomanometer (11). Systolic blood pressure was recorded for Korotkoff's first phase. Diastolic blood pressure was recorded in three-year-old children at the change in sound (when the sound begins to fade away), and for Korotkoff's fourth and fifth phases in the others. Korotkoff's fifth phase results were used in the analysis. Readings were made to the nearest 2 mmHg. The average of three measurements were used in the analysis. In 1986 and 2001, a random-zero sphygmomanometer was used.

Venous samples were drawn from the right antecubital vein of recumbent subjects after a 12 h fast. Serum cholesterol, triglyceride and apolipoprotein concentrations were determined as described previously (12,13). Because of changes in determination methods and kits during study years, lipid levels from 1980 and 1986 were corrected by using correction factor equations (12,13). These equations were determined with linear regression analysis using standardized principal component adjustments.

The daily intake of energy and quality of dietary fat were computed based on 48 h recall interviews (from one-half of the cohort) (14).

Statistical methods

Regression analysis (adjusted for age) was used to test whether secular trends from 1980 to 1986 were significant in subjects aged 15 to 18 years, and Student's *t* test was used to test secular trends from 1986 to 2001 in 24-year-old subjects. Concentrations for serum triglycerides were $\log_{10}$-transformed before analysis due to skewed distributions. The statistical tests were performed using SAS (SAS Institute, USA) and results were considered statistically significant at P<0.05 (two-tailed).

RESULTS

Lipids and apolipoproteins

Total cholesterol concentrations decreased from 1980 to 1986 (female subjects, delta=–0.19 mmol/L, P=0.003; male subjects, delta=–0.33 mmol/L, P<0.0001) and from 1986 to 2001 (female subjects, delta=–0.23 mmol/L, P=0.02; male subjects, delta=–0.38 mmol/L, P=0.002).

From 1980 to 1986, LDL-cholesterol concentrations decreased both in female (P<0.0001) and male (P<0.0001) subjects aged 15 to 18 years. From 1986 to 2001, LDL concentrations did not change in 24-year-old female (P=0.30) or male (P=0.26) subjects (Figure 1).

From 1980 to 1986, HDL-cholesterol concentrations did not change in female (P=0.12) or male (P=0.21) subjects, whereas from 1986 to 2001, they decreased significantly both in female (P<0.0001) and male (P<0.0001) subjects (Figure 2).

In male subjects, apolipoprotein A1 concentrations decreased from 1980 to 2001 (delta=–0.09 mmol/L, P=0.02) and from 1986 to 2001 (delta=–0.11 mmol/L, P=0.02). In female subjects, apolipoprotein A1 concentrations did not change from 1980 to 1986 (delta=0.02 mmol/L, P=0.58) or from 1986 to 2001 (delta=–0.08 mmol/L, P=0.23).

Triglyceride concentrations increased from 1980 to 1986 (female subjects, P<0.0001; male subjects, P<0.0001) and

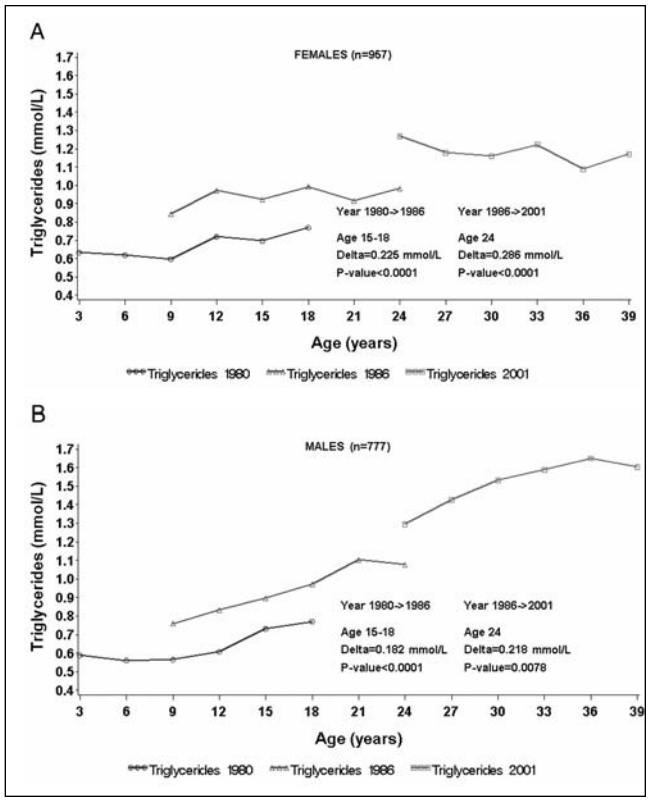

Figure 3) *Serum triglycerides in female (***A***) and male (***B***) Finns aged three to 39 years in 1980, 1986 and 2001*

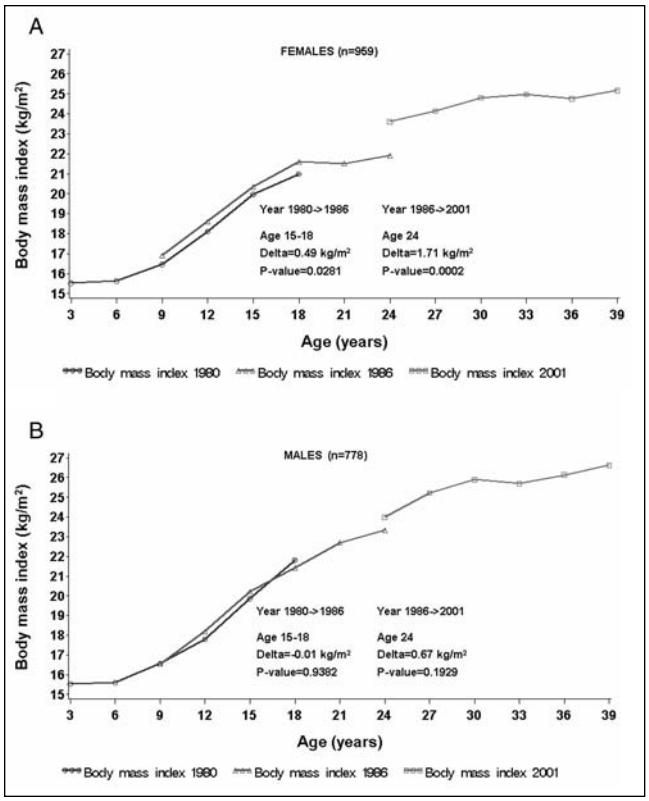

Figure 4) *Body mass index in female (***A***) and male (***B***) Finns aged three to 39 years in 1980, 1986 and 2001*

from 1986 to 2001 (female subjects, P<0.0001; male subjects, P=0.008) (Figure 3).

In male subjects, apolipoprotein B concentrations increased from 1980 to 1986 (delta=0.07 mmol/L, P=0.049) and from 1986 to 2001 (delta=0.14 mmol/L, P=0.02). In female subjects, apolipoprotein B concentrations did not change from 1980 to 1986 (delta=0.004 mmol/L, P=0.91) or from 1986 to 2001 (delta=0.07 mmol/L, P=0.21).

BMI

In female subjects, BMI levels increased from 1980 to 1986 (P=0.03) and from 1986 to 2001 (P=0.0002). In male subjects, BMI levels did not change from 1980 to 1986 (P=0.94) or from 1986 to 2001 (P=0.19) (Figure 4).

Blood pressure

Systolic blood pressure levels decreased from 1980 to 1986 (female subjects, P<0.0001; male subjects, P=0.0007) and from 1986 to 2001 (female subjects, P=0.001; male subjects, P<0.0001) (Figure 5). Diastolic blood pressure levels decreased from 1980 to 1986 (female subjects, P<0.0001; male subjects, P<0.0001) and from 1986 to 2001 (female subjects, P=0.006; male subjects, P=0.0001) (Figure 6).

Quantity of dietary energy and quality of dietary fats

In male subjects, the intake of dietary energy decreased borderline significantly from 1986 to 2001 (P=0.06). In female subjects, energy intake did not change from 1980 to 1986 or from 1986 to 2001 (P>0.15 for both) (Figure 7). In female subjects, the polyunsaturated/saturated fat (P/S) ratio did not change

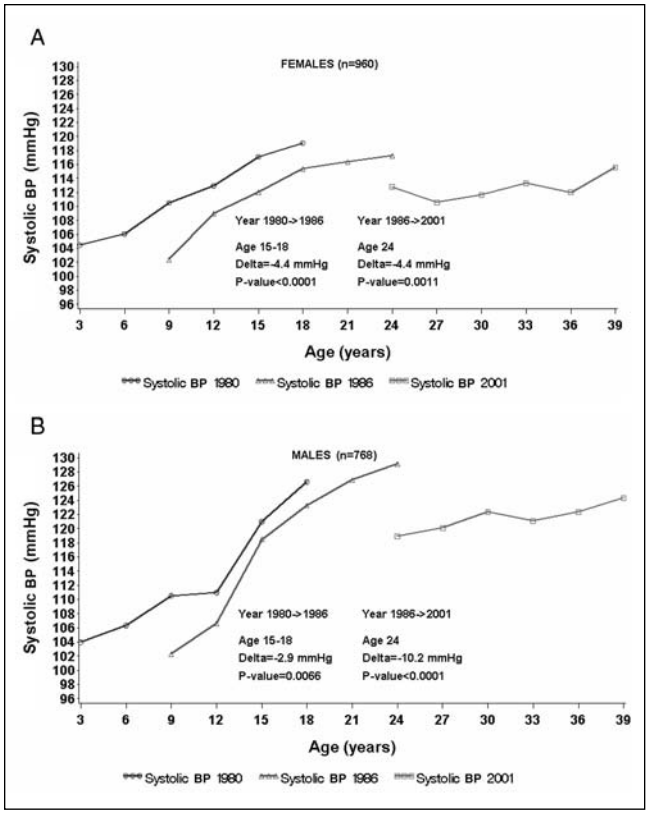

Figure 5) *Systolic blood pressure (BP) in female (***A***) and male (***B***) Finns aged three to 39 years in 1980, 1986 and 2001*

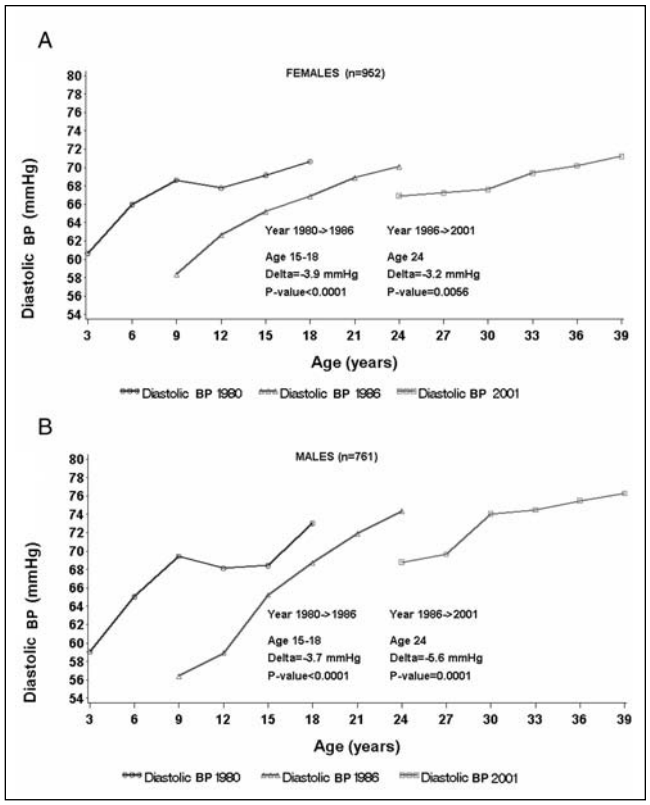

Figure 6) *Diastolic blood pressure (BP) in female (***A***) and male (***B***) Finns aged three to 39 years in 1980, 1986 and 2001. Diastolic blood pressure was measured at the change in sound in three-year-old children (using an ultrasound device), and at Korotkoff's fifth phase in the others (using a sphygmomanometer)*

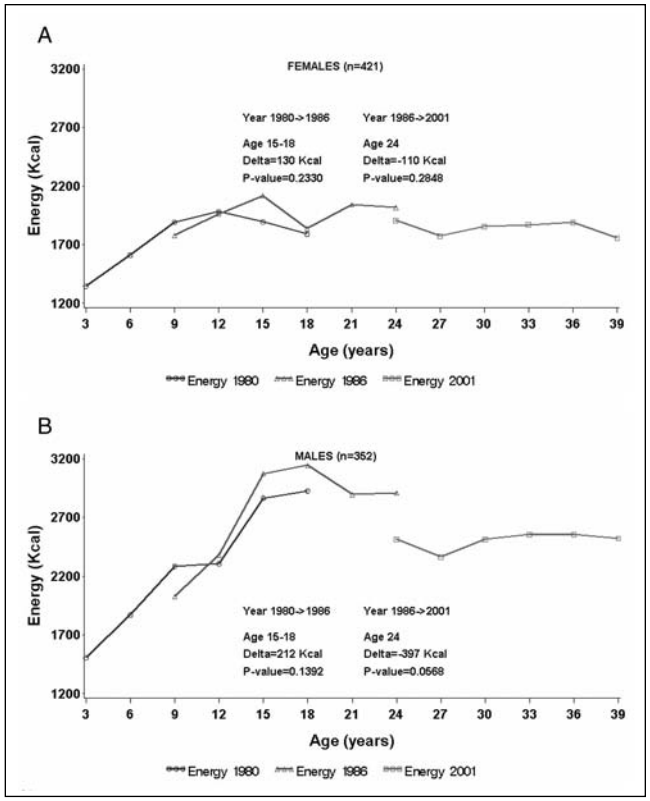

Figure 7) *The quantity of dietary energy in female (***A***) and male (***B***) Finns aged three to 39 years in 1980, 1986 and 2001*

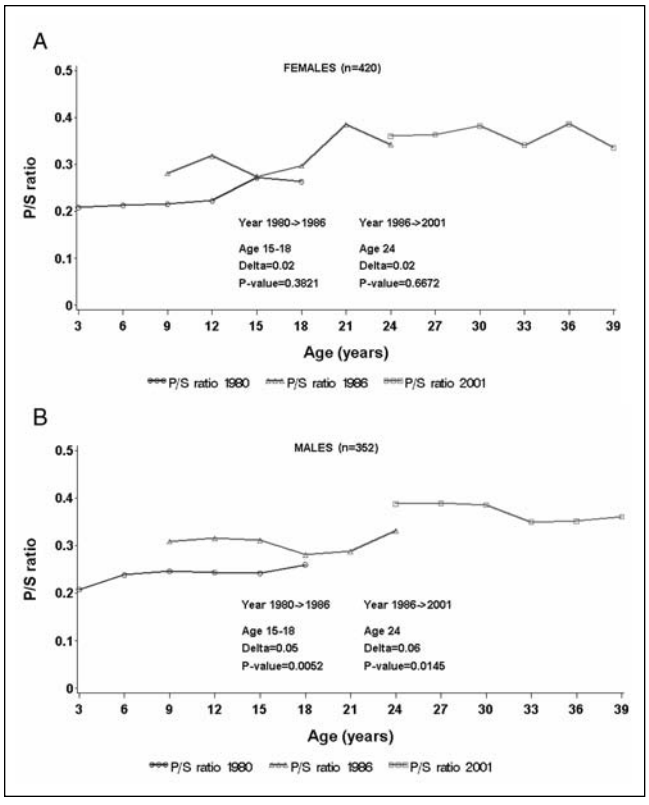

Figure 8) *The quality of dietary fat (ie, polyunsaturated/saturated fat [P/S] ratio) in female (***A***) and male (***B***) Finns aged three to 39 years in 1980, 1986 and 2001*

from 1980 to 1986 (P=0.38) or from 1986 to 2001 (P=0.67). In male subjects, the P/S ratio increased from 1980 to 1986 (P=0.005) and from 1986 to 2001 (P=0.01) (Figure 8).

DISCUSSION

The present follow-up study showed that decreases in LDL-cholesterol concentrations among young adults in Finland stopped between 1986 and 2001. At the same time, HDL-cholesterol concentrations began to decrease, and triglyceride concentrations continued to increase. In female subjects, BMI levels continued to increase. However, blood pressure levels continued to decrease in all subjects and, especially in male subjects, the P/S ratio of dietary fat continued to increase.

After the 1970s, cardiovascular risk factor levels improved and CAD mortality rates declined markedly in Finland (15-18). These results are presumably due to changes in dietary preferences and other lifestyle changes, as well as the development of medical care for CAD patients (19-21). However, the present follow-up study showed that LDL-cholesterol concentrations have not decreased in 24-year-old subjects since 1986. Moreover, results from the Finriski 2002 study showed that serum cholesterol concentrations did not decline from 1997 to 2002 in 25- to 74-year-old Finns (22). Thus, it seems that the declining trend in serum cholesterol concentration has slowed in Finland. The results obtained in the National Health and Nutrition Examination Survey (NHANES) from 1999 to 2000 in the United States are notably similar, showing no significant change in cholesterol concentrations compared with NHANES III performed between 1988 and 1994 (23).

We observed that HDL-cholesterol concentrations decreased and triglyceride concentrations increased very significantly from 1986 to 2001. Similar changes were shown in our earlier follow-up study (1980 to 1992) (12) and in another follow-up study performed in New England (United States) (24). The highly significant increase in triglyceride concentrations reflects the increase in apolipoprotein B concentrations, even though LDL-cholesterol concentrations decreased. These changes may be explained by changes in diet and by the increased BMI that was also observed in our study group, especially among female subjects. Saturated fat intake has decreased and polyunsaturated fat intake and carbohydrate intake has increased among Finnish and North American children during the past two decades (12,25). Supporting this, the present study observed a significant increase in the P/S ratio of male subjects. There has also been a trend toward increasing obesity in Western populations (12,26,27). These trends in diet and obesity have previously been linked with lipid changes similar to those found in the present study (12). Increased obesity is alarming because being overweight plays a pathophysiological role in the etiology of type 2 diabetes and metabolic syndrome, and both of these conditions have been linked to markedly increased CAD mortality (28,29).

In our study group, diastolic and systolic blood pressure levels continuously decreased from 1980 to 2001. Similarly, the Finriski study found that systolic blood pressure decreased by approximately 5% between 1987 and 1997 (15). However, after 1997, systolic blood pressure did not decrease among the Finriski subjects (22).

Study limitations

A potential limitation of our study is nonparticipation in the follow-up studies. However, we have shown that there are no differences in risk factor levels between participants and dropouts of the latest follow-up (in 2001) (13). Therefore, the present study cohort seems to be representative of the original study population. The observed decreases in blood pressure levels have some discrepancy with the secular trends observed in HDL-cholesterol, triglycerides, apolipoprotein B and BMI. This can be partly explained by the healthy participant effect; specifically, the participants who were 24 years of age in the 2001 investigation were in the study 15 years longer than the ones who were 24 years of age in 1986, and it is likely that the least healthy participants are prone to drop out earlier. This could have affected the secular trends in blood pressure, whereas the observed increases in triglycerides, apolipoprotein B and BMI and decrease in HDL-cholesterol probably more precisely reflect true trends. Therefore, in the population, the decrease in blood pressure may actually be slower than in our follow-up cohort. On the other hand, the changes observed in triglycerides, apolipoprotein B, HDL-cholesterol and BMI are in accordance with the trends in the increasing prevalence of the metabolic syndrome worldwide (30).

CONCLUSIONS

The secular trend of declining LDL-cholesterol concentrations has finished among young Finns, whereas HDL-cholesterol concentrations are decreasing and triglyceride and apolipoprotein B concentrations are increasing. In addition, there is a trend toward increasing obesity. Therefore, continuous monitoring of cardiovascular risk factors and more preventive work are needed, especially among young adults.

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