**Original Article**

# Serum fatty acids, lipoprotein (a) and apolipoprotein profiles of middle-aged men and women in South Vietnam

Nguyen Thi Minh Kieu[1] MD, Etsuko Yasugi[2] PhD, Nguyen Thi Kim Hung[3] MD, Toshimi Kido[4] BSc, Kazuo Kondo[4] MD, PhD, Shigeru Yamamoto[5] PhD, Nguyen Van Chuyen[1] PhD and Mieko Oshima[6] PhD

[1]*Department of Food and Nutrition, Japan Women's University, Tokyo, Japan*
[2]*Department of Hematology, Research Institute, International Medical Center of Japan, Tokyo, Japan*
[3]*Child Nutrition Center, Ho Chi Minh City, South Vietnam*
[4]*National Institute of Health and Nutrition, Tokyo, Japan*
[5]*Nutrition Department, School of Medicine, Tokushima University, Tokushima, Japan*
[6]*Tohoku University of Community Service and Science, Yamagata, Japan*

In Vietnam, increasing fat consumption is a trend recognized recently in urban areas. To obtain a reasonable nutrition status and prevent cardiovascular disease (CVD), it is necessary to obtain information on habitual fat intake and biochemical parameters as risk factors for CVD in Vietnamese populations. Therefore, from the analysis of serum fatty acid composition, fat consumption patterns in Vietnamese populations in South Vietnam, with different incomes, are discussed in this study. In addition, some risk factors for premature CVD, serum lipoprotein (a) and apolipoprotein concentrations are also assessed in these Vietnamese populations. The study was carried out in men and women aged 40–59 in three different districts: urban ($n$ = 100), suburban ($n$ = 98) and rural ($n$ = 98). The results of serum fatty acid composition analysis reflected differences in quality fat intake among the three populations. The urban population was estimated to consume more vegetable oil but less fish than their rural counterparts. Although serum lipoprotein (a) and apolipoprotein B levels were below the ranges associated with atherogenesis, ongoing attention to dietary fat intake for the prevention of CVD in Vietnamese populations is required.

**Key words: apolipoprotein, Can Gio district, cardiovascular disease, fatty acid composition, Ho Chi Minh City, lipoprotein (a), Vietnamese.**

## Introduction

Many epidemiological studies have demonstrated a positive association between high fat intake and a high incidence of cardiovascular disease (CVD). In Vietnam, although energy intake from fat is below 15%, increasing fat consumption is a trend reported recently in urban areas.[1] In our previous study, the fat intake of Northern Vietnamese people was observed to be significantly higher in urban than in rural areas,[2] but risk factors for premature CVD assessed by serum lipid, lipoprotein (a) and apolipoprotein (Apo) profiles were not found in all of these populations.[2,3] However, because fat consumption patterns are quite different in North and South Vietnam, the purpose of this study is to collect basic data allowing appropriate improvement of dietary fat quality and quantity for the whole country. Therefore, in this study, we analysed the serum fatty acid, lipoprotein (a) and apolipoprotein levels of Vietnamese people living in three districts, with different incomes, in South Vietnam. From the results of the analyses, the habitual fat intake was estimated for these populations and risk factors for premature CVD were assessed in male and female subjects in the age range associated with a high risk of CVD (40–59 years).

## Materials and methods

### *Subjects*

Three districts with different incomes were selected for this study: an urban area (Ben Thanh district), a suburban area (Nha Be district) and a rural area (Can Gio district). Ben Thanh is a high income trading area located in the centre of Ho Chi Minh City, where the majority of people are traders. Nha Be is an urbanised area inhabited by labourers with a medium income. Can Gio is a low income seaside community

**Correspondence address:** Nguyen Thi Minh Kieu, Department of Food and Nutrition, Japan Women's University, 2-8-1, Mejirodai, Bunkyo-ku, Tokyo 112-8681, Japan.
Tel: +81 3 3943 3131 Ext. 7123; Fax: +81 3 3942 6111
Email: kieu@jwu.ac.jp
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in which most of the people farm and fish for a living. In these selected districts, men and women aged 40–59 were selected randomly from the resident registration list provided by the Local People's Committee. None of them had CVD or endocrine metabolic diseases. The total number of subjects was 296: 100 in the Ben Thanh district, 98 in the Nha Be district and 98 in the Can Gio district. The sex, age and BMI (body mass index) of the subjects are shown in Table 1.

### *Analytical methods*

Blood was collected in the morning for a fasting blood test. Approximately 10 mL of blood was withdrawn and centrifuged. The serum was then stored frozen at – 80°C until the analyses. This study was approved by the Medical Ethics Committee of the Health Ministry of Ho Chi Minh City.

The serum fatty acid compositions were measured by means of gas–liquid chromatography (GLC), with a Shimadzu gas chromatograph (GC-14B; Shimadzu, Kyoto, Japan) equipped with a capillary column (silica Ulbon/HR-SS-10, 0.32 mm internal diameter × 50 mm). The conditions of analysis were the same as those described in our previous report.[2] The results were expressed as the percentage of the area of each fatty acid against the total area of all fatty acid peaks. Lipoprotein (a) and apolipoprotein concentrations were measured by immunoturbidimetry assay with an auto-analyser (Roche Cobas Mira, Tokyo, Japan).

### *Data analysis*

Serum fatty acid compositions were expressed as mean and standard deviation. One-way analysis of variance was used to compare mean values of continuous variables and to evaluate significant differences between groups. Lipoprotein (a) levels were reported as median and range, and compared between the groups by the non-parametric Kruskal–Wallis test.

## Results

### *Serum total fatty acids and fatty acid composition*

Serum total fatty acid (TFA) and fatty acid composition in men and women aged 40–59 years in the three districts are shown in Table 2. The amount of TFA did not differ significantly among these three populations for either men or women. In men, the saturated fatty acid (SFA) content, especially 16:0, was significantly lower in the urban than in the suburban and rural subjects. In men and women, the 16:1 content was lowest in the urban, higher in the suburban and highest in the rural population; the monounsaturated fatty acid (MUFA) content was also found to be significantly lower in urban than in suburban and rural subjects. Conversely, the polyunsaturated fatty acid (PUFA) and n-6 PUFA content, predominantly 18:2 n-6, was significantly higher in the urban than in the two other populations. As for the n-3 PUFA content, it was observed that the urban population had significantly lower 20:5 n-3, 22:5 n-3 and 22:6 n-3 levels, but higher 18:3 n-3 levels than their rural counterparts. The ratios of n-6 to n-3 were also shown to differ significantly among the three populations: 8.9, 6.8 and 5.2 for men and 8.4, 7.2 and 5.4 for women in urban, suburban and rural districts, respectively. The ratios of PUFA to SFA (P/S) were found to be approximately 1.0 in all of these populations.

### *Serum lipoprotein (a) and apolipoprotein concentrations*

The distribution curve of serum lipoprotein (a) levels was skewed towards the lower level in both sexes in all three populations, as shown in Fig. 1. The average, range and percentile values of serum lipoprotein (a) are presented in Table 3. In men, the average lipoprotein (a) levels did not differ among the three populations, but in women, they were significantly higher in the urban than in the rural subjects (Table 3). In this study, 95–100% of population in all three districts had cut-off lipoprotein (a) levels at 95th percentile below 30 μg/dL.

The serum concentrations of apolipoprotein AI, AII, B, CII, CIII and E are shown in Table 4. In men, Apo AI, Apo AII and Apo B levels were significantly lower in the urban than in the two other populations, while in women, only Apo I was significantly lower in the urban and suburban populations than in the rural population.

## Discussion

### *Fat intake*

From the results of serum fatty acid composition analysis, differences in habitual fat consumption were estimated in three Vietnamese populations. The high income urban population had a lower intake of MUFA but a higher intake of PUFA, particularly n-6 PUFA, than the suburban and the rural populations. The urban subjects consumed more 18:3 but less 20:5, 22:5 and 22:6 than the rural subjects. Because 18:3 n-3 is provided by vegetable oils while 20:5 and 22:6 n-3 are abundant in seafood, it was suggested that the rural population living in the seaside district may consume more fish but less vegetable oil than the urban population. Also, the intake of SFA was found to differ among male subjects of the three populations. As SFA (especially 16:0) is predominant in lard, one of the various kinds of fat frequently consumed in South

**Table 1.** Characteristics of subjects by sex in urban, suburban and rural populations of South Vietnam

| | Men | | | Women | | |
|---|---|---|---|---|---|---|
| | Urban ($n$ = 32) | Suburban ($n$ = 40) | Rural ($n$ = 39) | Urban ($n$ = 68) | Suburban ($n$ = 58) | Rural ($n$ = 59) |
| Age | 47.5 ± 5.5 | 46.6 ± 5.0 | 46.4 ± 4.7 | 47.5 ± 5.2 | 47.6 ± 6.4 | 47.2 ± 5.9 |
| BMI | 22.5 ± 2.6[a] | 21.2 ± 3.3[a] | 19.5 ± 2.3[b] | 22.4 ± 3.5[a] | 21.4 ± 3.7[a] | 19.9 ± 2.9[b] |

BMI, body mass index. Values within a row for the same sex with different superscript letters ([a–c]) are significantly different ($P < 0.05$).

**Table 2.** Serum total fatty acid and fatty acid composition in urban, suburban and rural populations of South Vietnam

| Fatty acid | Men | | | Women | | |
|---|---|---|---|---|---|---|
| | Urban ($n$ = 32) | Suburban ($n$ = 40) | Rural ($n$ = 39) | Urban ($n$ = 68) | Suburban ($n$ = 58) | Rural ($n$ = 59) |
| TFA (μg/mL) | 3141 ± 1904 | 3275 ± 1159 | 2822 ± 1079 | 2657 ± 812 | 2859 ± 844 | 2650 ± 808 |
| SFA% | 33.8 ± 1.9[a] | 35.2 ± 2.7[b] | 35.6 ± 2.7[b] | 34.4 ± 2.3 | 35.1 ± 2.0 | 34.4 ± 2.1 |
| 14:0 | 1.3 ± 0.6 | 1.3 ± 0.4 | 1.5 ± 0.5 | 1.4 ± 0.4 | 1.5 ± 0.4 | 1.4 ± 0.4 |
| 16:0 | 24.7 ± 1.7[a] | 26.2 ± 2.4[b] | 25.9 ± 2.1[b] | 25.1 ± 2.2[a] | 26.0 ± 2.1[b] | 24.8 ± 1.8[a] |
| 18:0 | 6.8 ± 0.5 | 6.8 ± 0.8 | 7.1 ± 0.7 | 7.0 ± 0.6 | 6.8 ± 0.6 | 7.1 ± 0.7 |
| 20:0 | 0.2 ± 0.04 | 0.2 ± 0.03 | 0.2 ± 0.08 | 0.2 ± 0.04 | 0.2 ± 0.03 | 0.2 ± 0.04 |
| 22:0 | 0.3 ± 0.09 | 0.2 ± 0.07 | 0.2 ± 0.08 | 0.3 ± 0.09 | 0.2 ± 0.06 | 0.3 ± 0.08 |
| 24:0 | 0.3 ± 0.1 | 0.3 ± 0.3 | 0.3 ± 0.1 | 0.3 ± 0.1 | 0.2 ± 0.09 | 0.3 ± 0.01 |
| MUFA% | 29.0 ± 4.1[a] | 31.0 ± 3.7[b] | 30.2 ± 3.3[b] | 27.1 ± 2.9[a] | 28.8 ± 2.9[b] | 29.6 ± 4.2[c] |
| 16:1 | 2.9 ± 1.0[a] | 3.8 ± 1.1[b] | 4.4 ± 1.2[c] | 3.4 ± 1.1[a] | 4.0 ± 1.2[b] | 4.8 ± 1.6[c] |
| 18:1 | 25.4 ± 3.9[a,b] | 26.6 ± 3.0[a] | 25.1 ± 2.7[b] | 23.0 ± 2.3[a] | 24.2 ± 2.4[b] | 23.9 ± 3.2[b] |
| 24:1 | 0.6 ± 0.2 | 0.6 ± 0.2 | 0.6 ± 0.1 | 0.6 ± 0.2[a] | 0.6 ± 0.2[a] | 0.8 ± 0.2[b] |
| PUFA% | 37.0 ± 5.1[a] | 33.7 ± 4.6[b] | 34.1 ± 4.1[b] | 38.3 ± 4.4[a] | 35.9 ± 3.9[b] | 35.9 ± 5.2[b] |
| n-6 PUFA% | 33.2 ± 4.8[a] | 29.3 ± 4.4[b] | 28.4 ± 4.1[b] | 34.1 ± 4.3[a] | 31.4 ± 3.6[b] | 30.1 ± 4.8 [b] |
| 18:2 n-6 | 25.6 ± 3.8[a] | 22.1 ± 4.0[b] | 20.4 ± 3.5[c] | 26.0 ± 3.9[a] | 23.7 ± 3.3[b] | 21.6 ± 4.1[c] |
| 18:3 n-6 | 0.2 ± 0.08 | 0.2 ± 0.1 | 0.3 ± 0.1 | 0.3 ± 0.1 | 0.3 ± 0.1 | 0.3 ± 0.1 |
| 20:3 n-6 | 1.0 ± 0.2 | 0.9 ± 0.2 | 1.1 ± 0.2 | 1.3 ± 0.3 | 1.2 ± 0.2 | 1.3 ± 0.2 |
| 20:4 n-6 | 6.2 ± 1.6 | 5.9 ± 1.3 | 6.5 ± 1.4 | 6.4 ± 1.4 | 6.2 ± 1.4 | 6.8 ± 1.5 |
| n-3 PUFA% | 3.8 ± 0.7[a] | 4.4 ± 0.8[b] | 5.6 ± 1.3[c] | 4.1 ± 0.7[a] | 4.4 ± 1.0[b] | 5.8 ± 1.0[c] |
| 18:3 n-3 | 0.5 ± 0.3[a] | 0.5 ± 0.1[a,b] | 0.4 ± 0.1[b] | 0.5 ± 0.2[a] | 0.5 ± 0.2[a] | 0.4 ± 0.1[b] |
| 20:5 n-3 | 0.5 ± 0.3[a] | 0.7 ± 0.2[b] | 1.4 ± 0.6[c] | 0.5 ± 0.2[a] | 0.7 ± 0.4[b] | 1.3 ± 0.6[c] |
| 22:5 n-3 | 0.4 ± 0.1[a] | 0.5 ± 0.2[b] | 0.8 ± 0.2[c] | 0.4 ± 0.09[a] | 0.4 ± 0.1[b] | 0.8 ± 0.2[c] |
| 22:6 n-3 | 2.2 ± 0.4[a] | 2.5 ± 0.5[b] | 3.0 ± 0.5[c] | 2.5 ± 0.5[a] | 2.7 ± 0.6[b] | 3.2 ± 0.6[c] |
| Ratio n-6/n-3 | 8.9 ± 1.7[a] | 6.8 ± 1.6[b] | 5.2 ± 1.4[c] | 8.4 ± 1.7[a] | 7.2 ± 1.5[b] | 5.4 ± 1.4[c] |
| Ratio P/S | 1.10 | 0.97 | 0.96 | 1.12 | 1.03 | 1.05 |

MUFA, monounsaturated fatty acid; n-6/n-3, the ratio of n-6 to n-3 PUFA; P/S, the ratio of PUFA to SFA; PUFA, polyunsaturated fatty acid; SFA, saturated fatty acid; TFA, total fatty acid. Values within a row for the same sex with different superscript letters ([a–c]) are significantly different ($P < 0.05$).

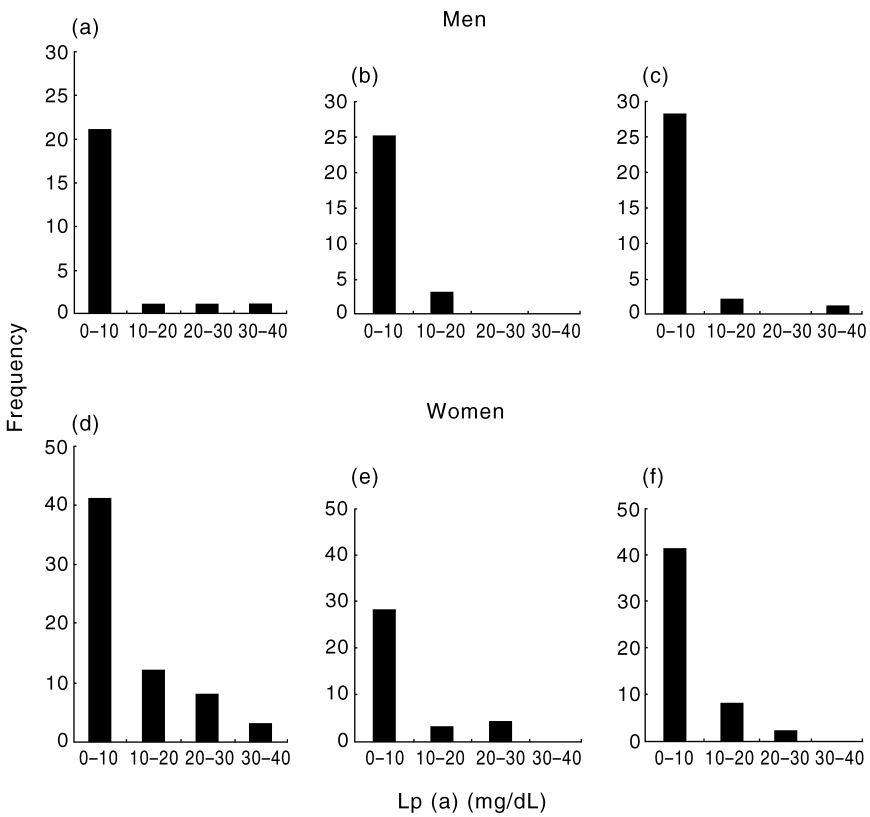


**Figure 1.** Distribution curves of serum lipoprotein (a) (Lp (a)) levels in male (a) urban, (b) suburban and (c) rural, and female (d) urban, (e) suburban and (f) rural populations.

Vietnam, men in the urban area may have lower lard consumption than those in suburban and rural areas.

The quality of fat consumed was also reflected in the P/S and n-6/n-3 ratios. The n-6/n-3 ratio was lowest in the rural, higher in suburban and highest in the urban subjects, probably because of the differences in fish and vegetable oil consumption among these three populations. The data on both percentage (Table 2) and absolute concentration (Table 5) of n-3 and n-6 content showed a higher fish consumption in the rural population (20:5, 22:5, 22:6 n-3), and a higher vegetable oil consumption in the urban population (18:2 n-6, 18:3 n-3). The World Health Organization (WHO) has recommended a ratio of n-6 to n-3 fatty acids of 5–10 : 1.[4] The distribution of dietary n-6 to n-3 ratios showed that 80% of the urban, 90% of the suburban and nearly 100% of the rural population had ratios in the range of 5–10 : 1 (calculated from raw data). Referring to the data on North Vietnamese people,[2] we found the P/S ratios to be equal in South and North Vietnam, while the average n-6/n-3 ratios were lower in the South than in the North. Because this study was performed in middle-aged people while the subjects of the study conducted in North Vietnam were adults over 18 years, there

**Table 3.** Serum lipoprotein (a) concentrations in urban, suburban and rural populations of South Vietnam

| Lipoprotein (a) (mg/dL) | Men | | | Women | | |
|---|---|---|---|---|---|---|
| | Urban ($n$ = 32) | Suburban ($n$ = 40) | Rural ($n$ = 39) | Urban ($n$ = 68) | Suburban ($n$ = 58) | Rural ($n$ = 59) |
| Mean ± SD | 6.1 ± 8.5 | 4.4 ± 4.1 | 5.2 ± 5.79 | 6 ± 9.3[a] | 8.1 ± 10.4[a,b] | 5.4 ± 5.7[b] |
| Median and range | | | | | | |
| 5th | 0.7 | 0.8 | 1.3 | 0.9 | 1.6 | 0.9 |
| 10th | 1.5 | 1.5 | 1.4 | 1.3 | 2.0 | 1.1 |
| 25th | 2.1 | 2.0 | 2.0 | 2.2 | 2.4 | 1.6 |
| 50th | 3.1 | 3.4 | 3.6 | 6.3 | 3.6 | 2.3 |
| 75th | 5.6 | 4.7 | 7.9 | 16.9 | 9.8 | 7.4 |
| 90th | 12.1 | 7.3 | 9.1 | 23.3 | 20.3 | 14.8 |
| 95th | 28 | 14.2 | 11.8 | 27.3 | 26.7 | 16.5 |

Values within a row for the same sex with different superscript letters ([a,b]) are significantly different ($P < 0.05$).

**Table 4.** Serum apolipoproteins concentrations (mg/dL) in urban, suburban and rural populations in South Vietnam

| Apolipoproteins (mg/dL) | Men | | | Women | | |
|---|---|---|---|---|---|---|
| | Urban ($n$ = 32) | Suburban ($n$ = 40) | Rural ($n$ = 39) | Urban ($n$ = 68) | Suburban ($n$ = 58) | Rural ($n$ = 59) |
| Apo AI | 99.1 ± 19.7[a] | 131.3 ± 37.9[b] | 125.6 ± 30.3[b] | 108.3 ± 25.5[a] | 118.3 ± 24.1[a] | 124.2 ± 29.1[b] |
| Apo AII | 22.5 ± 4.5[a] | 28.1 ± 8.9[b] | 26.4 ± 4.9[b] | 23.5 ± 5.1 | 23.7 ± 5.3 | 25.3 ± 5.5 |
| Apo B | 85.9 ± 18.9[a] | 103.4 ± 36.3[b] | 91.5 ± 32.0[b] | 83.2 ± 21.5 | 89.1 ± 27.7 | 86.9 ± 27.0 |
| Apo CII | 3.1 ± 1.8 | 4.1 ± 2.6 | 3.5 ± 1.7 | 2.6 ± 1.4 | 2.5 ± 1.5 | 2.2 ± 1.4 |
| Apo CIII | 7.6 ± 2.7 | 9.6 ± 5.1 | 8.6 ± 2.9 | 6.7 ± 2.5 | 7.1 ± 2.4 | 6.5 ± 2.1 |
| Apo E | 3.3 ± 1.1 | 4.0 ± 1.8 | 3.7 ± 1.7 | 2.9 ± 0.9 | 3.7 ± 1.1 | 3.2 ± 0.9 |

Values within a row for the same gender with different superscript letters ([a,b]) are significantly different ($P < 0.05$). Apo, apolipoprotein.

**Table 5.** Serum n-6 and n-3 content in urban, suburban and rural populations of South Vietnam

| Fatty acid (μg/mL) | Men | | | Women | | |
|---|---|---|---|---|---|---|
| | Urban ($n$ = 32) | Suburban ($n$ = 40) | Rural ($n$ = 39) | Urban ($n$ = 68) | Suburban ($n$ = 58) | Rural ($n$ = 59) |
| n-6 PUFA | 999 ± 446[a] | 940 ± 299[b] | 793 ± 275[b] | 890 ± 230[a] | 888 ± 234[b] | 787 ± 237[b] |
| 18:2 n-6 | 778 ± 391[a] | 709 ± 242[a] | 573 ± 220[b] | 679 ± 193[a] | 668 ± 179[a] | 566 ± 182[b] |
| 18:3 n-6 | 8 ± 7 | 9 ± 6 | 9 ± 5 | 9 ± 5 | 9 ± 5 | 9 ± 5 |
| 20:3 n-6 | 32 ± 10 | 31 ± 13 | 31 ± 11 | 36 ± 14 | 35 ± 13 | 36 ± 12 |
| 20:4 n-6 | 180 ± 52 | 190 ± 63 | 180 ± 55 | 166 ± 45 | 176 ± 58 | 176 ± 55 |
| n-3 PUFA | 119 ± 75[a] | 142 ± 50[a] | 157 ± 6[b] | 110 ± 37[a] | 127 ± 40[b] | 151 ± 50[c] |
| 18:3 n-3 | 23 ± 41[a] | 17 ± 10[a,b] | 12 ± 8[b] | 15 ± 12[a] | 15 ± 8[a] | 11 ± 5[b] |
| 20:5 n-3 | 17 ± 10[a] | 25 ± 11[b] | 38 ± 19[c] | 15 ± 8[a] | 20 ± 8[b] | 34 ± 8[c] |
| 22:5 n-3 | 13 ± 6[a] | 18 ± 7[b] | 23 ± 10[c] | 12 ± 4[a] | 14 ± 5[a] | 22 ± 9[b] |
| 22:6 n-3 | 66 ± 24[a] | 82 ± 29[b] | 85 ± 31[b] | 68 ± 2[a] | 77 ± 26[b] | 85 ± 27[b] |

Values within a row for the same sex with different superscript letters ([a–c]) are significantly different ($P < 0.05$). PUFA, polyunsaturated fatty acid.

is a possibility that the habitual consumption of foods rich in n-3 PUFA is lower in young than in older subjects.

On the basis of these observations, the key question is, what are the proper ratios of P/S and n-6/n-3 PUFA in the Vietnamese diet? Although there is no firm evidence to support appropriate and healthy dietary fatty acid levels, the habitual fat consumption in Japan seems to serve as a criterion for the recommended allowance, as judged from the low incidence of CVD and the life expectancy of the Japanese people. The Japanese currently consume about 26% of total energy as fats with P/S and n-6/n-3 PUFA ratios of 1.2 : l and 4 : 1, respectively.[5] In comparison with the Vietnamese diet, the Japanese diet has a higher n-3 PUFA content. Food sources such as fish, shellfish and some vegetable oils, such as soybean oil and rapeseed oil, are the most important sources of n-3 PUFA, which provide substantial amounts of this fatty acid in the Japanese diet.[5] Thus, for the current Vietnamese low fat diet (with fat providing 10–15% of total energy), an increase in fat consumption is necessary to attain the recommended dietary allowance of a fat energy ratio of 20%.[6] In addition, in order to improve the balance between n-6 and n-3 PUFA in the diets of Vietnamese populations, the consumption of fish, seafood and vegetable oils rich in n-3 PUFA, such as soybean oil, should be encouraged.

### *Lipoprotein (a), apolipoprotein and premature CVD*

In this study, certain risk factors were evaluated for premature CVD in men and women aged 40–59 years. The lipoprotein (a) levels of both sexes in the three populations were below the range associated with atherogenesis, expressed as 30 mg/dL.[7] All three of these populations had values of serum total cholesterol (TC), triglyceride (TG), high density lipoprotein cholesterol (HDL-C) and low density lipoprotein cholesterol (LDL-C) that were within the normal range. The TC/HDL-C ratios observed in both sexes of the three populations were all approximately four, which is below the target ratio (six in women and seven in men)[8] for the beginning of a CVD intervention. However, the values of serum TC were found to be significantly higher in the urban than in the rural population (182 mg/dL in urban and 153 mg/dL in rural men; 177 mg/dL in urban and 160 mg/dL in rural women). As for serum apolipoprotein concentrations, the data from both men and women showed, the urban subjects to have significantly lower Apo AI values than their rural counterparts, and the Apo B levels were all below the intervention value of Apo B at the 90th percentile (150 mg/dL).[8] Thus, based on the data obtained in this study and that of our previous study in North Vietnam, the risk factors for premature CVD were not observed in these Vietnamese populations in either urban or rural areas. However, given the transitional situation of Vietnam in these times of rapid economic development, increases in non-communicable chronic diseases related to dietary fat, such as obesity, diabetes and hypertension, have been reported.[1] A prevention strategy aimed at reducing CVD risk in the future is therefore of interest.

## Conclusion

From this study we obtained basic data on habitual fat intake, as well as serum lipoprotein (a) and apolipoprotein profiles, in three districts with different incomes in South Vietnam. These data, along with our previous data from North Vietnam, provide a source of information for appropriate improvement of dietary fat intake in Vietnamese people throughout the country in terms of both fat quantity and quality.

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