The Effect of Milk and Skim Milk Intake on Serum Lipids and Apoproteins in Postmenopausal Females

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Summary The effects of milk and skim milk intake on serum lipids, apoprotein levels and fatty acid composition were investigated in postmenopausal females. After a 25-day intake of 200 ml/day of whole milk, the milk group had increased HDL and LDL cholesterol levels, with a slight decrease in the proportion of 18:0 fatty acids in the phospholipid fraction. The skim milk group, which had consumed 20 g/day of skim milk for 25 days, showed no changes. After intake of 400 ml/day of whole milk for 29 days, LDL, HDL and total cholesterol concentrations were even more increased and the VLDL-phospholipid concentration was decreased, with significant increases in apoA-I, apoA-II and apoB concentrations. In the skim milk group, consuming 40 g of skim milk per day for 29 days, total cholesterol, atherogenic index, HDL-triglyceride concentrations were decreased and HDL-phospholipid, apoA-I and apoA-II concentrations were increased. Daily skim milk consumption, which is effective in preventing osteoporosis, and careful selection of foods should be recommended for Japanese postmenopausal women who consume more than 200 ml/day of whole milk.

Key Words milk, skim milk, lipoprotein lipids, apoprotein, postmenopausal women, fatty acids

In postmenopausal women, the secretion of female sex hormones ceases and increased parathyroid hormone sensitivity accelerates the bone resorption which causes osteoporosis. Calcium intake alone, at the recommended dietary requirement of 600 mg a day in Japan, is not sufficient (1). Therefore, milk consumption is recommended for prevention and treatment of osteoporosis as milk is an excellent source of calcium. However, ordinary whole milk contains more than 3.5% milk fat and higher levels of saturated fat than plant oil. In previous studies, the consumption of whole milk or dairy products has been suggested to increase serum
cholesterol (2–5), and hypocholesterolemic effects have also been reported (6, 7). Bearing in mind the atherogenic properties of milk, nutritionists can not recommend consumption of adequate amounts of milk to maintain high serum calcium levels because the volumes required (over 200 ml/day; about one large glass of milk) carry the risk of unfavorably elevating serum cholesterol and fatty acid levels.

In our previous study, we compared the effects of milk and skim milk intake on serum lipid and apoprotein levels in young adult normolipidemic females, taking into consideration the effects of menstrual cycles. An intake of 400 ml/day of whole milk did not change either total or individual lipoprotein cholesterol levels (8). In this study, the effects of milk and skim milk intake on serum lipid and apoprotein concentrations and fatty acid composition were investigated in order to find the optimal quantity and type of milk for postmenopausal women.

METHODS

Subjects consisted of seventeen postmenopausal female volunteers aged 48–72 years, living in Bunkyo-ku, Tokyo. The purpose of the experiment had been explained to them and their consent was obtained. Preexperimental period questionnaires concerning eating habits were obtained and the subjects were divided into two groups, i.e., milk and skim milk consumption. The diet was not controlled before the start of experiment, and blood was drawn in the morning after overnight fasting (period N). The milk group subjects drank 200 ml of milk which contained more than 3.5% milk fat, and the skim milk group subjects drank 20 g of skim milk with approximately the same content of calcium as the 200 ml of whole milk for 25 days, daily (period I). Then the milk group drank 400 ml of milk, and the skim milk group drank 40 g of skim milk for 29 days, daily (period II). The nutrient contents of the milk and skim milk have been reported in a previous paper (8). Blood samples were drawn in the morning after overnight fasting for each period.

Serum was separated into very low density lipoprotein (VLDL), low density lipoprotein (LDL), high density lipoprotein 2 (HDL₂) and high density lipoprotein 3 (HDL₃) by ultracentrifugation (9). Cholesterol concentration was determined by an enzymatic method (Fuji Rebio Co., Ltd., Tokyo). Triglyceride and phospholipid concentrations were also determined by an enzymatic method (Kokusai Shiyaku Co., Ltd., Tokyo). Apoproteins were measured by single radial immunodiffusion (Daiichi Kagaku Co., Ltd., Tokyo).

Fatty acid analysis was done as follows: Lipids were extracted from 1 ml of serum by the method of Folch et al. (10). Thin-layer chromatography with Silica gel (Merck, Darmstadt, Germany) was used to separate the fatty acid fractions by use of petroleum ether, diethyl ether, and acetic acid (84.15:15.0:0.85, v/v/v). After separation the fatty acids within the triglyceride and phospholipid fractions were scraped into Teflon-lined, screw-cap glass tubes and methylated under argon gas in a heat block at 100°C for 30 min by using 3.5% sulfuric acid in methanol. The fatty acid methyl esters were extracted with petroleum ether and separated by

J. Nutr. Sci. Vitaminol.
gas-liquid chromatography (Shimadzu GC-12A gas-liquid chromatograph, Tokyo, Japan) using a 3 mm × 2.1 m glass packing column containing diethyleneglycol succinate on 60–80 mesh Chromosorb W (Nihon Chromato Works Ltd., Tokyo, Japan). Injector and column temperatures were 230°C and 200°C, respectively. Nitrogen was employed as the carrier gas.

Diet records were kept for 3 days before the day the blood samples were obtained in each period, and nutrient intakes were calculated.

The significance of the data was analyzed by paired t-test.

RESULTS

The age, age at menopause, height, weight, body mass index, and systolic and diastolic blood pressure of each of the subjects are shown in Table 1. There were no significant differences between the two groups. In the skim milk group, systolic blood pressure decreased in period II as compared to period N (p < 0.05).

Serum cholesterol concentrations and atherogenic indices for each period are shown in Table 2. In the milk group, the serum total cholesterol concentration (TCH) increased from period N to period II (p < 0.05), with increasing concentrations of HDL and LDL cholesterol. The atherogenic index (A.I.) did not change during the experiment. In the skim milk group, the TCH decreased significantly from period N to period II (p < 0.01) with a tendency for the LDL cholesterol concentration (LDL-CH) to decrease, but with a tendency for HDL to increase, especially the HDL2 cholesterol concentration (HDL2-CH). A.I. decreased in period II as compared to period N (p < 0.05).

Serum triglyceride concentrations (TG) are shown in Table 3. In the milk

Table 1. Age, age at menopause, height, weight, BMI, SBP and DBP.

| Group        | Milk          | Skim milk     |
|--------------|---------------|---------------|
| Number of subjects | 9             | 8             |
| Age          | 59.9 ± 7.0*   | 59.3 ± 5.3    |
| Age at menopause | 49.1 ± 2.7    | 49.5 ± 3.7    |
| Height (cm)  | 153.3 ± 5.5   | 153.9 ± 7.4   |
| Weight (kg)  |               |               |
| N period     | 54.2 ± 8.5    | 51.6 ± 6.7    |
| N period     | 22.9 ± 2.5    | 21.8 ± 2.3    |
| I period     | 23.1 ± 2.8    | 21.9 ± 2.3    |
| II period    | 23.1 ± 3.0    | 21.9 ± 2.3    |
| SBP (mmHg)   |               |               |
| N period     | 130.0 ± 17.3  | 123.8 ± 18.4  |
| I period     | 127.1 ± 15.2  | 122.3 ± 11.5  |
| II period    | 128.4 ± 11.8  | 120.0 ± 20.0  |
| DBP (mmHg)   |               |               |
| N period     | 76.2 ± 10.3   | 77.0 ± 14.0   |
| I period     | 73.1 ± 9.1    | 72.5 ± 12.5   |
| II period    | 76.0 ± 6.1    | 70.5 ± 14.8   |

*Mean ± SD. *p < 0.05.

Vol. 38, No. 2, 1992
Table 2. Serum cholesterol concentrations and atherogenic index.

| Group  | Milk       | Skim milk  |
|--------|------------|------------|
|         | N period   | I period   | II period  |
| TCH (mg/dl) | 222±35*    | 216±35     |            |
| VLDL-CH (mg/dl) | 227±32 *    | 213±36 **  | 207±32     |
| LDL-CH (mg/dl) | 239±34     |            |            |
|         | N period   | I period   | II period  |
|         | 16.8±11.2  | 15.8±14.4  |            |
|         | 8.9±6.3    | 11.4±10.5  |            |
|         | 10.0±6.9   | 12.1±11.6  |            |
|         | N period   | I period   | II period  |
|         | 144.8±32.9 | 137.6±34.6 |            |
|         | 153.7±29.3 | 139.6±35.5 |            |
|         | 161.1±31.6 | 127.9±34.2 |            |
|         | N period   | I period   | II period  |
|         | 60.7±13.0  | 63.1±16.6  |            |
|         | 64.8±13.0  | 62.3±13.9  |            |
|         | 67.9±12.2  | 67.7±19.2  |            |
|         | N period   | I period   | II period  |
|         | 38.6±11.0  | 41.3±14.0  |            |
|         | 41.1±11.4  | 40.0±12.7  |            |
|         | 44.5±13.0  | 45.2±19.5  |            |
|         | N period   | I period   | II period  |
|         | 22.1±3.6   | 21.8±3.7   |            |
|         | 23.7±3.0   | 22.6±3.1   |            |
|         | 23.4±3.9   | 22.6±3.1   |            |
| A.I.    | N period   | I period   | II period  |
|         | 2.48±0.77  | 2.46±1.21  |            |
|         | 2.45±0.61  | 2.42±1.04 *|            |
|         | 2.46±0.70  | 2.17±1.14  |            |

*Mean±SD. *p<0.05, **p<0.01.

Table 3. Serum triglyceride concentrations.

| Group    | Milk       | Skim milk  |
|----------|------------|------------|
|         | N period   | I period   | II period  |
| Total TG (mg/dl) | 96±36*    | 83±38      |            |
|         | 77±25      | 79±40      |            |
|         | 84±22      | 85±39      |            |
| VLDL-TG (mg/dl) | 45.3±25.7  | 36.0±33.3  |            |
|         | 30.9±20.5  | 36.4±28.4  |            |
|         | 35.5±17.4  | 40.9±35.1  |            |
| LDL-TG (mg/dl) | 32.1±11.8  | 29.7±10.1  |            |
|         | 29.8±6.8   | 26.2±5.3   |            |
|         | 33.8±10.1  | 28.9±7.1   |            |
| HDL-TG (mg/dl) | 18.3±3.7   | 17.5±2.6   |            |
|         | 16.2±2.8   | 16.6±2.8 * |            |
|         | 14.6±3.3   | 15.3±4.8   |            |

*Mean±SD. *p<0.05.

In the skim milk group, TG were unaffected by the intake of milk. In the skim milk group, only the HDL triglyceride concentration (HDL-TG) decreased in period II as compared to period N (p<0.05), and no significant changes were observed in LDL and VLDL.
triglyceride levels.

Serum phospholipid concentrations (PL) are shown in Table 4. In the milk group, the VLDL phospholipid concentration (VLDL-PL) decreased in period II as compared to period N \((p<0.05)\). In the skim milk group, VLDL-PL also tended to decrease but not significantly. The HDL phospholipid concentration (HDL-PL) increased in period II as compared to the N and I periods \((p<0.05)\).

Table 4. Serum phospholipid concentrations.

| Group       | Period | Milk       | Skim milk  |
|-------------|--------|------------|------------|
| Total PL (mg/dl) | N period | 216±27* | 210±24     |
|             | I period | 221±27 | 205±24     |
|             | II period | 226±28 | 210±27     |
| VLDL-PL (mg/dl) | N period | 13.9±8.6 | 13.8±10.2  |
|             | I period | 9.6±7.6 * | 14.3±7.8  |
|             | II period | 7.1±5.5 | 9.9±9.7    |
| LDL-PL (mg/dl) | N period | 93.6±20.2 | 87.3±18.8  |
|             | I period | 96.6±16.5 | 84.3±19.6  |
|             | II period | 116.4±19.5 | 80.7±18.6 |
| HDL-PL (mg/dl) | N period | 108.5±20.5 | 108.4±23.9  |
|             | I period | 114.4±20.3 | 106.5±19.6 * |
|             | II period | 102.7±19.5 | 119.4±27.8 * |

*Mean±SD. *p<0.05.

Table 5. Apoprotein concentrations.

| Group | Period | Milk       | Skim milk  |
|-------|--------|------------|------------|
| apoA-I (mg/dl) | N period | 138±24* | 138±19     |
|        | I period | 130±17 *** | 129±21   |
|        | II period | 155±12 | 149±23    |
| apoA-II (mg/dl) | N period | 31.3±4.8 | 30.0±5.3   |
|        | I period | 29.7±4.7 | 28.8±3.5   |
|        | II period | 34.2±4.9 ** | 32.5±5.1 ** |
| apoB (mg/dl) | N period | 101±18 | 97±28      |
|        | I period | 99±14 * | 91±20     |
|        | II period | 108±19 | 95±26      |
| apoC-II (mg/dl) | N period | 4.1±1.1 | 3.0±0.9    |
|        | I period | 3.8±0.8 | 3.6±1.3    |
|        | II period | 4.5±0.9 | 3.7±1.3   |
| apoC-III (mg/dl) | N period | 9.4±1.9 | 8.0±2.0    |
|        | I period | 9.3±1.7 | 8.2±1.6    |
|        | II period | 10.3±2.1 | 9.0±1.7 |
| apoE (mg/dl) | N period | 4.3±0.7 | 5.0±1.6    |
|        | I period | 4.6±0.6 * | 5.3±0.9   |
|        | II period | 4.9±0.9 | 4.7±0.9    |

*Mean±SD. *p<0.05, **p<0.01.
Table 6. Serum triglyceride fatty acid compositions.

| Group | Milk | Skim milk |
|-------|------|-----------|
|       | N period | 24.3±4.2* | 24.9±4.0 |
|       | I period  | 24.5±2.7  | 24.4±3.0 |
|       | II period | 25.7±4.7  | 25.8±3.2 |
|       | N period  | 3.7±1.0   | 3.8±0.7  |
|       | I period  | 4.0±0.8   | 3.3±0.6  |
|       | II period | 3.9±0.7   | 3.8±0.6  |
|       | N period  | 36.8±3.5  | 35.6±4.0 |
|       | I period  | 36.8±4.5  | 37.3±3.8 |
|       | II period | 35.4±2.5  | 36.0±2.7 |
|       | N period  | 24.1±5.8  | 21.7±5.5 |
|       | I period  | 22.7±4.3  | 21.7±4.8 |
|       | II period | 22.8±5.5  | 21.3±4.2 |
|       | N period  | 1.7±0.4   | 1.7±0.4  |
|       | I period  | 1.7±0.3   | 2.7±2.0  |
|       | II period | 1.7±0.4   | 1.7±0.4  |
|       | N period  | 1.1±0.5   | 1.6±0.8  |
|       | I period  | 1.6±1.3   | 1.3±0.5  |
|       | II period | 1.3±0.6   | 1.7±1.0  |
|       | N period  | 0.2±0.0   | 0.2±0.1  |
|       | I period  | 0.1±0.1   | 0.2±0.1  |
|       | II period | 0.2±0.1   | 0.3±0.4  |
|       | N period  | 3.7±1.9   | 5.9±3.2  |
|       | I period  | 5.1±3.5   | 4.7±1.5  |
|       | II period | 4.3±2.3   | 4.6±1.5  |

*Mean±SD.

Serum apoprotein concentrations are shown in Table 5. In the milk group, all apoprotein concentrations tended to increase in period II as compared to the early periods of this experiment. More significant increases were observed in the apoA-I, apoB, and apoE concentrations in period II than in period N (apoA-I, p<0.01; apoB and apoE, p<0.05). In addition, the apoA-I and apoA-II concentrations decreased slightly in period I, so that their levels were higher in period II than in period I (p<0.01). In the skim milk group, the apoA-I and A-II concentrations increased in period II as compared to period I, while the other apoproteins were unaffected by skim milk consumption.

Fatty acid compositions of serum triglycerides and phospholipids are shown in Tables 6 and 7. The proportion of 18:0 fatty acids in serum phospholipids decreased with milk consumption (p<0.05), but the composition was unchanged, in terms of other fatty acids.

Mean nutrient intakes for 3 days during each period are shown in Table 8. In the milk group, calcium, riboflavin and ascorbic acid intakes were increased in periods I and II as compared to period N, the difference appearing between periods.
EFFECT OF MILK AND SKIM MILK INTAKE ON SERUM LIPIDS

Table 7. Serum phospholipid fatty acid composition.

| Group | Period | Milk       | Skim milk  |
|-------|--------|------------|------------|
| 16:0  | N      | 29.9 ± 1.5 | 30.3 ± 0.8 |
|       | I      | 30.6 ± 1.1 | 29.8 ± 1.0 |
|       | II     | 30.1 ± 1.4 | 30.6 ± 0.7 |
| 18:0  | N      | 15.5 ± 1.5 | 14.6 ± 1.0 |
|       | I      | 14.4 ± 1.0 | 14.6 ± 1.0 |
|       | II     | 14.4 ± 1.0 | 14.7 ± 1.2 |
| 18:1  | N      | 9.8 ± 0.9  | 10.1 ± 1.0 |
|       | I      | 10.0 ± 1.4 | 10.3 ± 0.8 |
|       | II     | 9.2 ± 0.8  | 10.3 ± 0.7 |
| 18:2  | N      | 20.1 ± 2.9 | 18.3 ± 4.1 |
|       | I      | 20.0 ± 3.5 | 20.3 ± 2.8 |
|       | II     | 20.4 ± 2.5 | 20.1 ± 3.9 |
| 20:4  | N      | 8.5 ± 1.1  | 7.9 ± 1.1  |
|       | I      | 8.7 ± 1.1  | 7.9 ± 0.7  |
|       | II     | 8.6 ± 1.0  | 7.6 ± 0.9  |
| 20:5  | N      | 3.1 ± 1.3  | 4.1 ± 1.5  |
|       | I      | 3.7 ± 2.1  | 3.5 ± 0.8  |
|       | II     | 3.4 ± 1.0  | 3.6 ± 1.1  |
| 22:0  | N      | 3.1 ± 0.4  | 2.8 ± 0.6  |
|       | I      | 3.0 ± 0.7  | 2.9 ± 0.7  |
|       | II     | 3.2 ± 0.6  | 3.0 ± 0.8  |
| 22:6  | N      | 8.6 ± 1.1  | 10.0 ± 2.0 |
|       | I      | 8.4 ± 1.2  | 9.9 ± 1.4  |
|       | II     | 8.5 ± 1.0  | 9.2 ± 1.5  |

* Mean ± SD. *p < 0.05.

I and II. Lipid intake was not significantly increased by the consumption of milk which contains at least 7 g of fat in 200 ml and 14 g in 400 ml. In the skim milk group, calcium, protein, phosphorus and riboflavin intakes were increased in period II as compared to period N.

DISCUSSION

In this study, 200 ml and 400 ml of whole milk provided 130 and 260 kcal, 254 and 508 mg of calcium, and 7 and 14 g of fat, respectively, while 20 g and 40 g of skim milk provided 70 and 140 kcal, 225 and 450 mg of calcium, and 0.2 and 0.4 g of fat, respectively. Consumption of 200 ml of milk produced comparable increase in calcium intake but other nutrients, most notably fat, were significantly different. We expected a doubling of the observed increase in nutrient contents of the milk or skim milk but found that it was somewhat less than these with consumption of 400 ml of whole milk and 40 g of skim milk. Thus, we can surmise that the consumption of other foods and eating patterns might have a slight change when, in older
Table 8. Nutritional intakes.

| Group              | Milk                  | Skim milk             |
|--------------------|-----------------------|-----------------------|
| Energy (kcal)      | N period: 1,616±313** | 1,901±202             |
|                    | I period: 1,793±219   | 1,940±270             |
|                    | II period: 1,693±254  | 1,960±376             |
| Protein (g)        | N period: 74.1±15.8   | 77.3±8.0              |
|                    | I period: 73.8±11.2   | 87.0±10.1**           |
|                    | II period: 76.0±17.7  | 92.4±13.9             |
| Lipid (g)          | N period: 49.7±11.4   | 60.0±11.4             |
|                    | I period: 63.9±13.0   | 58.0±14.0             |
|                    | II period: 55.3±12.0  | 52.6±13.3             |
| Carbohydrate (g)   | N period: 215.7±35.0  | 251.1±43.3            |
|                    | I period: 225.5±27.1  | 253.3±39.6            |
|                    | II period: 220.4±45.8 | 269.2±58.5            |
| Fiber (g)          | N period: 4.8±1.1     | 4.4±0.8               |
|                    | I period: 6.0±3.6     | 4.5±1.4               |
|                    | II period: 4.4±1.1    | 4.7±1.1               |
| Calcium (mg)       | N period: 702±183†    | 709±119               |
|                    | I period: 909±168 *   | 813±133**             |
|                    | II period: 919±234    | 930±156               |
| Phosphorus (mg)    | N period: 1,103±237   | 1,127±149             |
|                    | I period: 1,152±158   | 1,334±139             |
|                    | II period: 1,307±264  | 1,437±216             |
| Iron (mg)          | N period: 11.2±3.0    | 11.0±1.7              |
|                    | I period: 12.2±4.7    | 11.6±3.0              |
|                    | II period: 10.4±2.7   | 11.3±3.5              |
| Sodium (mg)        | N period: 3,957±1,321 | 4,534±727             |
|                    | I period: 3,977±783   | 5,269±1,745           |
|                    | II period: 3,786±785  | 4,726±1,038           |
| Potassium (mg)     | N period: 2,964±531   | 3,010±332             |
|                    | I period: 3,258±258   | 3,288±642             |
|                    | II period: 3,170±628  | 3,589±682             |
| Retinol potency (IU)| N period: 2,594±1,372 | 2,943±704             |
|                    | I period: 2,874±806   | 2,638±939             |
|                    | II period: 3,617±2,223| 3,351±1,301           |
| Thiamin (mg)       | N period: 1.03±0.20   | 1.08±0.29             |
|                    | I period: 1.12±0.27   | 1.23±0.22             |
|                    | II period: 1.06±0.25  | 1.31±0.32             |
| Riboflavin (mg)    | N period: 1.42±0.31   | 1.50±0.24             |
|                    | I period: 1.78±0.19   | 1.75±0.23**           |
|                    | II period: 1.80±0.36  | 1.97±0.31             |
| Niacin (mg)        | N period: 14.7±3.2    | 14.6±2.3              |
|                    | I period: 15.8±4.1    | 17.1±3.4              |
|                    | II period: 15.8±4.8   | 18.9±5.9              |
| Ascorbic acid (mg) | N period: 108±23 **   | 107±34                |
|                    | I period: 164±43 **   | 134±52                |
|                    | II period: 170±40     | 188±98                |

*Mean±SD. *p<0.05, **p<0.01.

J. Nutr. Sci. Vitaminol.
women, the diet is loaded with a volume of milk as large as 400 ml or skim milk as large as 40 g.

In previous studies subjects have been young men or women, and milk consumption for several months resulted in no significant changes in TCH. There was a slight increase in TCH which was considered to represent a physiological adaptation to the fat and cholesterol intake, which the subjects were initially unaccustomed to, in the early periods of the experiments (11, 12). We added 400 ml of milk to the diets of young women. No other milk or dairy products were permitted. VLDL-CH and VLDL-PL rose with an increase in apoB, but these levels were in midnormal range, in our previous study (8). These results suggested that when subjects are normolipidemic initially, the lipid load provided by whole milk might be catabolized very quickly. In this study, however, consumption of 400 ml/day of milk by postmenopausal women whose TCH level was at the borderline for hypercholesterolemia, significantly increased LDL-CH, HDL-CH, TCH, apoA-I, apoA-II, apoB and apoE along with a slight decrease in VLDL lipids, suggesting that VLDL is efficiently metabolized to LDL or HDL but that the LDL pool is increased. Nevertheless the atherogenic index was maintained at the initial level. One possible explanation for these differences between young women and postmenopausal women might be an effect of estrogen. Concomitantly with menopause, decreased estrogen secretion causes a decrease in LDL uptake by the liver (13, 14).

We designed this study to determine whether intake of 400 ml/day of milk, which contains only 14 g of milk fat and 46 mg of cholesterol, affects cholesterol metabolism in postmenopausal women. Several epidemiological studies have suggested that over an energy intake from fat exceeding 35% and a low P/S ratio are important risk factors for hypercholesterolemia and coronary heart disease (15–18). In the milk group in this study, the fat contribution to total energy intake was 27% and 29%, a little higher than the Japanese recommended dietary requirement for fat intake, during the N and II periods, respectively. Milk was the source of about 25% of total dietary fat and provided 16:0, 18:1, 18:0, and 14:0 fatty acids. But the proportion of 18:0 fatty acid in serum phospholipids decreased and no connection between whole milk consumption and fatty acid composition was observed. Ueshima et al. (study periods: 1975–1977) reported a strong positive correlation between the dietary lipid factor of Keys et al. and serum total cholesterol level for Japanese men whose fat intakes were between 11 and 23% of total energy (19). Sacks et al. showed that lactovegetarians whose percentages of energy intake from fats resembled those of our subjects, consuming dairy products as the major source of saturated fatty acids, had higher LDL-CH and HDL-CH levels than strict vegetarians. In addition, the log P/S ratio correlated inversely and dietary cholesterol correlated positively with LDL-CH (20). These results suggested that consuming 400 ml/day of whole milk, taking into consideration the minor contribution of other food intake, might be the upper volume limit for maintaining A.I. at the high end of the normal range in postmenopausal Japanese women with
high fat intakes, above 25% of total energy, from other foods.

On the other hand, a cholesterol-lowering effect was also found when 40 g/day of skim milk were consumed, as in previous studies (8, 11, 12). Significant decreases in TCH and A.I., with increasing apoA-I and apoA-II concentrations, which did not appear in our study of young females (8), indicate a passive decrease in LDL particles and an increase in HDL especially the HDL2 particle. In postmenopausal women whose TCH levels were in the highest end of the normal range, skim milk consumption was considered to effectively lower serum cholesterol. Slight changes in the energy percentage from fat (in conjunction with changes in protein intake) might also be expected to affect cholesterol metabolism. But sources of polyunsaturated fatty acids, i.e., fish, plant oils, or dietary fiber from seaweed, fruits and cereals were consumed regularly in Japan, so the mechanisms underlying the differences between the milk and skim milk groups require further clarification.

Bierenbaum et al. reported that dietary calcium supplementation using 1.0 quart of 2% fat milk or skimmed milk providing 1,400 mg of calcium daily for 6 months decreased systolic and diastolic blood pressure, and decreased serum cholesterol slightly (21).

Skim milk consumption, for the prevention of osteoporosis, seems to have parallel effects in preventing hypercholesterolemia.

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