MILK AND MILK PRODUCTS CONSUMPTION IN RELATIONSHIP TO SERUM LIPID LEVELS: A COMMUNITY-BASED STUDY OF MIDDLE-AGED AND OLDER POPULATION IN JAPAN

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SUMMARY

The authors examined the association of milk and milk products consumption (MMPC) with serum lipid profiles including total cholesterol (TC), triacylglycerols (TG), HDL cholesterol (HDLC), LDL cholesterol (LDLC), and TC/HDLC ratio in a community-based sample. The study population comprised 461 men and 834 women aged 40-79 years who, in 2001, participated in an annual healthy examination and a lifestyle related survey. Consumption frequency of 17 foods, including milk and milk products, was determined by a self-administered questionnaire. The participants were asked by "Do you drink cow's milk or eat milk products such as yoghurt and cheese everyday?", and two groups ("Yes" and "No") of MMPC were classified. Multiple linear regression analyses were conducted to examine the relationships between MMPC and 5 serum lipid profile levels adjusted for sex, age, body mass index (BMI), alcohol consumption, smoking, physical activity, and fat intake. Univariate and multivariate analyses indicated inverse associations of MMPC with TC, HDLC, and LDLC, and that the "Yes" group had higher adjusted means of serum TC by 7.133 mg/100 ml (p<0.001), HDLC by 1.844 mg/100 ml (p<0.05), LDLC by 5.459 mg/100 ml (p<0.001). We suggested that MMPC has an association with serum lipid and lipoprotein levels and that MMPC may have an unfavorable effect on hypercholesterolaemia in the Japanese population.

Key words: serum lipids, milk and milk products consumption, lifestyle, hypercholesterolaemia, Japanese

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INTRODUCTION

With the coming of aged society, the incidence and mortality of cardiovascular disease (CVD) have been increasing rapidly in recent years in Japan, and deaths which include cardiac infarction and stroke have increased more than cancer (1). Large epidemiological studies have shown that hypercholesterolemia is widely recognized as a risk factor for CVD (2-5). In Japan, daily consumption of whole milk and other milk products (cheese, skimmed milk, yogurt, ice cream, etc) was 107 g/day in the Nutrition Survey (6). Milk and milk products consumption have been becoming a common daily dietary with westernization of lifestyle. Previous study has reported that a glass of milk (200 ml) consumption per day improved bone health in Japan (7). On the other hand, higher milk and milk consumption may increase fat intake, for example, 200 ml of whole milk has 6.8 g of fat and 22 mg of cholesterol. It is well known that fat intake is the major risk factor of hypercholesterolaemia, therefore milk and milk products consumption may subsequently affect lipid metabolism and risks for CVD. In this report, the relationships between milk and milk products consumption and serum lipid levels were examined in a community-based sample of 467 men and 851 women aged 40-79 years.

POPULATION AND METHODS

Study Design

This study comprised 1,592 residents more than 20 years of age who participated in the annual physical examination for the year 2001 in Ano town of Mie Prefecture, located in the central region of Japan. We selected the participants aged from 40 to 79 years (N=1,308) as the subjects of analysis. Mean age of the subjects was 63.3±9.9 years. The execution of this study was approved by the Ethical Board of Community Center. The health examination was conducted by an occupational health organization, included standardized measurements of height, weight, and serum lipids and lipoproteins. Consumption frequency of 17 foods, including milk and milk products, current or previous tobacco smoking, current alcohol consumption and physical activity in leisure time were included in a self-administered questionnaire handed in at the screening examination.

Determination of Serum Lipids

The Mie Health Management Center agreed to the joint study of chemical analysis, and processing of serum specimens for total cholesterol, HDL cholesterol, and triacylglycerols. Chemical analyses, editing and data processing were also performed at this Center.

Approximately 56 per cent of examinees were fasting at the time of the examination. The serum was recovered and frozen within one hour of collection. The serum lipid analyses were performed after about two weeks of frozen storage. Serum TC and TG were determined by enzymatic methods using autoanalyzers. HDLC cholesterol was determined by a heparin and manganese chloride precipitation method. LDLC cholesterol was calculated by the formula of Friedewald and colleagues. TC/HDLC ratio was calculated in all subjects.

Definitions

MMPC. MMPC was classified into Yes/No groups by a self--administered questionnaire "Do you drink cow's milk or eat milk products such as yogurt and cheese everyday?".

Body mass index. BMI was calculated as weight in kilograms divided by the square of height in meters, which is then used to categorize weight into: "Underweight" (BMI<20), "Normal" (BMI 20-24.9) and "Obesity" (BMI≥25), according New Japanese Obesity Classification (8).

Frequency of alcohol consumption. The frequency of consumption of beer, wine or sake was obtained from the lifestyle questionnaire during the health examination. Participants were asked about their usual consumption of alcoholic beverages during the 3 months that preceded the examination. Consumption was classified as: never, sometimes (one or two times one week), and daily (one or more times per day).

Tobacco consumption. "Never smokers" were those who had never smoked in their entire lives. "Ex-smokers" were those who reported smoking cigarettes but weren't smoking at the time of the survey. "Current smokers" were those who reported smoking daily at the time of the survey.

Physical activity. Two questions dealt with physical activity. Participants were asked (1) whether they were walking for 30 minutes or more every day and (2) whether they were doing intense exercise one or two times every week. The higher category of activity in the two questions was then calculated as a composite of activity of any kind.

Fat intake. By using a question "Do you always eat fat of meat?" , two groups ("Yes" and "No") of fat intake were classified.

Statistical Analysis

By using t-test, serum lipid levels were compared between "Yes" and "No" groups on MMPC by sex specific. Multiple linear regression techniques assessed each of the serum lipids between milk and milk products consumption and independently from the effects of sex, age, BMI, alcohol consumption, tobacco consumption, physical activity, and fat intake. Analysis of covariance (ANCOVA) was used to calculate mean serum lipids by milk and milk productions consumption adjusted for the confounding factors. All computations were performed by using the SPSS release 11.0 statistical package (9).

RESULTS

Table 1 presents the descriptive characteristics of the subjects. "Yes" group on MMPC was 57% and 73% in men and women, respectively.

Table 1. Characteristics of 461 men and 834 women aged 40-79 years by milk and milk products consumption, serum lipid profiles and selected variables

	Male (n=461)		Female (n=834)	
	Mean (SD)	%	Mean (SD)	%
Age (years)	65.7 (8.6)	•••	61.0 (10.3)	•••
BMI (kg/m²)	23.2 (2.9)	•••	22.8 (3.1)	•••
Serum lipid levels (mg/100 ml)				
TC	203.7 (35.2)	•••	221.3 (33.5)	•••
TG	153.9 (84.7)	•••	138.9 (77.1)	•••
HDL	53.0 (13.9)	•••	61.3 (14.1)	•••
LDL	115.0 (28.9)	•••	123.6 (27.3)	•••
TC/HDLC	4.1 (1.1)	•••	3.8 (1.1)	•••
MMPC (yes)	•••	57	•••	73
Daily alcohol consumption	•••	35	•••	4
Current cigrette smoker	•••	24	•••	2
No leisure-time physical activity	•••	32	•••	41
Fat intake	•••	41	•••	27

Table 2 compares the sex-specific serum lipids according to the "Yes" and "No" groups on MMPC by t-test. For men, crude analysis showed that the "Yes" group had significant higher serum LDLC levels by 5.39 mg/100 ml than the "No" group (p<0.05). For women, the "Yes" group had significant higher levels of serum TC by 9.49 mg/100 ml (p<0.001), HDLC by 2.77 mg/100 ml (p<0.05), and LDLC by 5.71 mg/100 ml than the "No" groups, respectively. TG levels and TC/HDLC ratio had no significant difference between the two groups in both men and women.

A multiple linear regression model with MMPC and seven other factors was then examined (Table 3). After controlling for sex, age, BMI, drinking, smoking, exercise, and fat intake, the "Yes" group on MMPC had higher significantly adjusted means of TC by 7.133 mg/100 ml (p<0.001), HDLC by

Table 2. Means (SE) of serum lipids for adults aged 40-79 years, by sex§

Serum lipids	MMPC	Male (n=461)		Female (n=834)	
		Mean	Difference	Mean	Difference
TC	Yes	205.71		223.88	
	No	200.93	4.78	214.39	9.49***
TG	Yes	152.16		136.89	
	No	156.19	-4.02	142.88	-5.99
HDLC	Yes	53.06		62.05	
	No	52.93	0.14	59.29	2.77*
LDLC	Yes	117.33		125.21	
	No	111.94	5.39*	119.49	5.71**
TC/HDLC	Yes	4.086		3.804	
	No	4.036	0.50	3.792	0.01

§ t-test tests for unadjusted differences between "Yes" and "No" groups
* p<0.05, **p<0.01, *** p<0.001

Table 3. Multiple linear regression analysis of milk and milk products consumption and other selected factors on serum lipids

	Serum lipids (mg/100 ml)				
	TC	TG	HDLC	LDLC	TC/HDLC
Sex (female/male)	18.630***	-3.627	8.397***	7.846***	-0.234**
Age (years)	0.044	0.264	-0.105**	-0.038	0.001*
BMI (kg/m²)	1.521***	7.221***	-1.402***	1.504***	0.118***
MMPC (Yes/No)	7.133***	-6.171	1.844*	5.459***	0.001
Daily alcohol consumption	2.070	5.733	2.547***	-0.986	-0.114
Current smoker	0.496	2.787*	-0.778**	1.350	0.006*
No leisure-time physical activity	-0.062	-4.547	0.126	1.316	-0.002
Fat intake (Yes/No)	3.730*	3.729	-0.667	2.881*	0.110

* p<0.05, **p<0.01, ***p<0.001

1.844 mg/100 ml (p<0.05), LDLC by 5.459 mg/100 ml (p<0.01) than the "No" group. No significant relationship between MMPC and serum TG and TC/HDLC was shown in this model. Table 3 also shows the effects of seven other factors on serum lipids.

Table 4 shows the mean difference of the serum lipids between the "Yes" group and "No" groups on MMPC after adjusting for seven other variables by ANCOVA. The "Yes" group was 7.133 mg/100 ml (3.4%) higher means of TC (217.493 vs. 210.360 mg/100 ml, p<0.001), 1.844 mg/100 ml (3.2%) higher means of HDLC (58.998 vs. 57.153 mg/100 ml, p<0.05), and 5.459 mg/100 ml (4.7%) higher means of LDLC (122.412 vs. 116.953 mg/100 ml, p<0.01) than the "No" group. MMPC had some more effects on serum TC and LDLC than serum HDLC.

DISCUSSION

In the present community-based study of middle-aged and older Japanese population, we demonstrated that MMPC was

Table 4. Mean serum lipids (SE) by milk and milk pruducts consumption adjusted for sex, age, BMI, drinking, smoking, physical activity, and fat intake in 461 men and 834 women aged 40-79 §

Serum lipids	MMPC	Mean (SE)	Difference (Yes-No, %)
TC	Yes	217.49 (1.15)	
	No	210.36 (1.67)	3.4***
TG	Yes	142.18 (2.61)	
	No	148.35 (3.77)	-4.2
HDLC	Yes	59.00 (0.45)	
	No	57.15 (0.66)	3.2*
LDLC	Yes	122.41 (0.93)	
	No	116.95 (1.35)	4.7**
TC/HDLC	Yes	3.90 (0.03)	
	No	3.89 (0.05)	0.3

§ Based on analysis of covariance
*p<0.05, **p<0.01, ***p<0.001

positively associated with serum TC, HDLC, and LDLC significantly negatively associated with serum TG, although the relation was not statistically significant, and had no relation to TC/HDLC ratio.

Many epidemiological studies (2-5) have demonstrated that hypercholesterolaemia, raised serum LDLC level, is a major risk factor for CVD. Oppositely, high serum HDLC level and low TC/HDLC ratio are protective against CVD. In the present study, both the risk factors (serum TC and LDLC) and the protective factors (serum HDLC) for CVD were increasing with MMPC. Nevertheless, MMPC may have more effect on serum TC and LDLC than HDLC, due to the "Yes" group had higher adjusted serum TC (7.13, +3.4%) and LDLC (5.46, +4.7%), contrasting with serum HDLC (1.84, +3.2%) than "No" group, and there was no relation between MMPC and TC/HDLC ratio. These results suggests that MMPC has had some more unfavorable effects on serum lipid profile and slightly increased risks for CVD rather than it has improved the profile and is protective against CVD.

A glass of whole milk (200 ml) contains 6.8 g fat, about two thirds of which are saturated, and 22 mg cholesterol (10). Ney (11) has reported that hypercholesterolaemia effect of milk consumption may be due to saturated fat in milk, but not to its cholesterol content. Although the current ratio of fat intake in Japan is much less than that in the Western countries (6), the amount of saturated fat in even one glass of milk may be enough to affect serum lipid and lipoprotein profiles. In this study, there is a negative relationship between MMPC and fat intake (p=-0.06, data were not shown), and as a confounding factor fat intake was analyzed in the multivariate analyses. The basic relationship that was apparent in the univarite analyses persisted even after controlling for fat intake.

Many studies have shown that there were negative relationships between use of skimmed/low-fat milk and fermented milk and serum TC (12-16). In this study, MMPC was assessed as the "Yes" and "No" groups, and detail nutritional status was not assessed. However, 73 per cent Japanese are consuming whole milk according the investigation of Japanese milk and dairy products consumption trend (17). The consumption of skimmed/low-fat milk and fermented milks is still limited. Furthermore, skimmed milk supplementation had hypocholesterolaemic effects on serum lipid on subjects with high serum TC concentration, but not on ones with low TC concentration (18, 19). Therefore, more consumption of skim/low-fat milk and fermented milks may improve serum lipids and lipoprotein in the Japanese, especially in individuals with hypercholesterolaemia. Jacobsen et al. (13) have documented that serum TG level decreased with consumption of milk production. In this study we also found a trend of lower serum TG levels decreased by MMPC, i.e., serum TG levels were lower in "Yes" group than in the "No" group, although a significant difference was not found.

Previous studies (4, 20-23) have discussed the effect of seven other confounding factors considered in the multiple regression analysis (Table 3) on serum lipids. Our study is in agreement with previous observations, of which aging, obesity and tobacco smoking had unfavorable effects on serum lipids and lipoproteins profile and increased risks for CVD. Contrary, women, alcohol consumption and habitual exercise improved the profile and decreased the CVD risk.

CONCLUSION

In conclusion, this study added to the body of evidence suggesting that MMPC had an association with serum lipid and lipoprotein levels and that MMPC might have an unfavorable effect on hypercholesterolaemia in the middle-aged and older Japanese, but low-fat dairy products could be used to provide adequate calcium for optimal bone health. Underlying mechanisms of hypercholesterolaemia with MMPC remain to be elucidated in the further studies.

REFERENCES

1. Health and Welfare Statistics Association: Journal of health and welfare statistics. PP47-48, 2002. (In Japanese.)
2. Manson JE, Tosteson H, Ridker PM, et al.: The primary prevention of myocardial infarction. N Engl J Med 1992; 326(21):1406-16.
3. Levine GN, Keaney JF Jr, Vita JA. Cholesterol reduction in cardiovascular disease: Clinical benefits and possible mechanisms. N Engl J Med. 1995; 332(8):512-21.
4. Stamler J, Daviglus ML, Garside DB, et al.: Relationship of baseline serum cholesterol levels in 3 large cohorts of younger men to long-term coronary, cardiovascular, and all-cause mortality and to longevity. JAMA 2000 Jul 19;284(3):311-8.
5. Huhtasaari F, Asplund K, Wester PO: Cardiovascular risk factors in the Northern Sweden MONICA Study. Acta Med Scand 1988;224(2):99-108.
6. Health Promotion and Nutrition Section, Ministry of Health and Welfare: National Nutrition Survey 1997. Tokyo, Daiichi Shuppan, 1999. (In Japanese.)
7. Yoshida H, Nagaya T, Hayashi T, Takahashi H, et al.: Milk consumption decreases activity of human serum alkaline phosphatase: a cross-sectional study. Metabolism 1995; 44:1190-1193.
8. Matsuzawa Y, Inoue S, Ikeda Y, et al.: New decision of obesity and overweight diagnosis criteria. Obesity Res 2000; 6 (1): 18-28 (In Japanese.)
9. SPSS Inc. SPSS Base 11.0 for Windows User's Guide. Chicago, 2001.
10. The Resources Council, Science and Technology Agency: Tables of Fatsoluble Composition of Food in Japan (Fatty acid, cholesterol and vitamin E). Tokyo, Ministry of Finance, 1999. (In Japanese.)
11. Ney DM: Potential for enhancing the nutritional properties of milk fat. J Dairy Sci 1991 Nov;74(11):4002-12.
12. Volpe R, Niittynen L, Korpela R, Sirtori C, Bucci A, Fraone N, Pazzucconi F. Effects of yoghurt enriched with plant sterols on serum lipids in patients with moderate hypercholesterolaemia. Br J Nutr 2001 Aug;86(2): 233-9.
13. Jacobsen BK, Thelle DS: The Tromso Heart Study: food habits, serum total cholesterol, HDL cholesterol, and triglycerides. Am J Epidemiol 1987 Apr;125(4):622-30.
14. Richelsen B, Kristensen K, Pedersen SB. Long-term (6 months) effect of a new fermented milk product on the level of plasma lipoproteins-a placebo-controlled and double blind study. Eur J Clin Nutr 1996 Dec;50(12): 811-5.
15. Solvoll K, Selmer R, Loken EB, et al. Coffee, dietary habits, and serum cholesterol among men and women 35-49 years of age. Am J Epidemiol 1989 Jun;129(6):1277-88.
16. Jacobsen BK, Stensvold I.: Milk - a better drink? Relationships with total serum cholesterol in a cross-sectional survey. The Nordland Health Study. Scand J Soc Med 1992 Dec;20(4):204-8.
17. The National Dairy Promotion and Research Association: Investigation of Japanese milk and dairy products consumption trend. PP7, 2001. (In Japanese.)
18. Buonopane GJ, Kilara A, Smith JS, et al. Effect of skim milk supplementation on blood cholesterol concentration, blood pressure, and triglycerides in a free-living human population. J Am Coll Nutr 1992 Feb;11(1):56-67.
19. Ashar MN, Prajapati JB. Verification of hypocholesterolemic effect of fermented milk on human subjects with different cholesterol levels. Folia Microbiol (Praha). 2000;45(3):263-8.
20. Chi D, Nakano M, Yamamoto K. Correlates of serum high-density lipoprotein cholesterol: a community-based study of middle-aged and older men and women in Japan. Asia Pac J Publ Health 2003;15(1):17-22.
21. Linn S, Fulwood R, Rifkind B, et al. High density lipoprotein cholesterol levels among US adults by selected demographic and socioeconomic variables: the Second National Health and Nutrition Examination Survey 1976-1980. Am J Epidemiol 1989;129:281-294.
22. Nakanishi N, Tatara K, Nakamur K, et al. Association of lifestyle with seerum lipid levels: a study of middle-aged Japanese men. J Epidemiol 1999;10:216-225.
23. Criqui MH. The roles of alcohol in the epidemiology of cardiovascular diseases. Acta Med Scand 1987;717 (suppl):73-85.