지 역 사 회 영 양 학 회 지 3(5) : 715~721, 1998
Korean J Community Nutrition 3(5) : 715~721, 1998

☐Original Article☐

The Effect of Milk Supplementation on Bone Density and Iron Status of Elderly

Sook Mee Son,† Yeh Na Chon

Department of Food and Nutrition, The Catholic University of Korea, Puchon, Korea

ABSTRACT

This study was performed to investigate how milk supplementation can benefit the elderly by increasing bone density but possibly harming the iron status concomitantly. Forty one elderly subjects over 65 years of age(male : 9, female : 32) participated. All subjects were apparently healthy, home staying and attending meal service for lunch at the welfare center. They were from low income area of Puchon city. One cup of milk per day was served for 10 months. The mean intake of calcium was significantly increased for females after milk supplementation. Males showed significantly increased means of triceps skinfold thickness, suprailiac skinfold thickness and waist circumference. Females showed significantly increased measurements of three kinds of skinfold thickness, waist circumference, and hip circumference. There were no significant change in the mean bone density of lumbar spine(L_2~L_4), femoral neck, ward's triangle and torchanter, but the proportion of osteopenia estimated by the T score of lumbar spine bone density was lowered from 50.0% to 34.6% for females. The mean Hb level was significantly reduced for males and the mean RBC count, Hb, serum ferritin were significantly decreased for males. The proportion of anemia estimated by Hb(<12g/dl), Hct(<36%) and serum ferritin(<15ng/ml) were increased from 17.2% to 51.7%, from 20.7% to 44.8% and from 10.3% to 17.2%, respectively for females. It looks like milk supplementation can effect the intakes of several nutrients considered to be commonly deficient in the Korean diet of elderly people, increase some anthropometric measurements, and decrease the proportion of osteopenia. However it can have adverse effects on iron status of females. (*Korean J Community Nutrition* 3(5) : 715~721, 1998)

KEY WORDS : elderly · milk supplementation · bone density · iron status.

Introduction

Decline in bone mass with age is a universal process in the elderly. Multiple factors have been reported to be related to bone health, including genetic differences(Pocock et al. 1987), physical activity(Stillman et al. 1986), postmenopausal estrogen loss(Riggs & Melton 1988), smoking(Daniel 1976), and dietary factors(Cum-mings et al. 1985 ; Heaney 1987).

Among the dietary factors thus far investigated, calcium has long been considered to be the most important. Considerable evidence for a strong positive association between dietary calcium intake and bone density has been provided by various studies(Elder et al. 1991 ; Smith et al. 1989 ; Son & Chon 1998). In contrast, other investigators have reported no protective effect of high calcium intake(Riggs et al. 1987).

It was observed that the intake of calcium for the

†**Corresponding author** : Sook Mee Son, 43-1 Yokkok 2-dong Wonmigu, Puchon city, Kyonggi-do 422-743, Korea
Tel : 032) 340-3318, Fax : 032) 340-3111
E-mail : sonsm@www.cuk.ac.kr

elderly in Korea was increasing(Park 1994 ; Park 1996). But Korean elderly living in urban areas were still observed as having low calcium intake and bone density(Son & Chon 1998). They(1998) reported elderly living in low income areas of Puchon had mean calcium intake of 308 – 331mg(44.1 – 53.9% RDA) and positive correlation with bone density($P<0.01$). The mean bone density of lumbar spine was 0.998 g/cm^2 and 0.825 g/cm^2 for male and female, respectively. The proportion of osteoporosis estimated by the T score(< – 2.5) of lumbar spine bone density was 18. 4% for males and 50.0% for females. Milk and dairy products, which account for 60 – 75% of calcium intake in the United States, were not consumed by most of the elderly surveyed. It is regarded that milk supplementation is a convenient and easy way to increase the calcium intake of elderly. Whereas milk supplementation can reduce iron absorption and can have harmful effects on iron status. Hallberg et al.(1991) demonstrated that iron absorption was reduced by 50 – 60% at doses between 300 – 600mg of Ca and giving 165mg calcium as milk also reduced absorption by 50 – 60%. It is recommen-cded that when calcium is administered to the elderly, the iron status should be monitored.

It was demonstrated that the calcium intake of the elderly before milk supplementation was about 320mg, which can be inceased to about 525mg(75% RDA) by adding a cup of milk per day.

In this study we investigated that milk supplementation can befenit the elderly by increasing bone density but possibly harming the iron status concomitantly.

Subjects and Methods

1. Subjects and milk supplementation

Forty-one elderly subjects over 65 years of age(male : 9, female : 32) participated in the study. All subjects were apparently healthy, home staying and attending meal service for lunch at the welfare center. They were from low income area of Puchon city.

It was showed that the minimum months of calcium supplementation needed for changes in bone density was 9 months(Smith et al. 1989), serving one cup of milk(200ml) per day with meal service at the welfare center started in June 1996 and lasted for 10 months. One cup of milk contained 200mg of calcium. All measurements were repeated at the end of 10 months period.

2. Bone density measurements

The bone mineral density(BMD) of the lumbar spine ($L_2 – L_4$), femoral neck, wards' triangle and trochanter were determined by using X-ray absorptiometry(Lunar PPX-alpha, USA 1994).

3. Evaluation of food consumption

Data of twenty-four hour recall for breakfast, dinner and snack were collected at the participant's home by a trained dietition. The amount of foods consumed at lunch was weighed directly. This was done for 3 consecutive days between April and May, 1996. The average daily dietary intake of nutrients was calculated by using a computerized data base based on Foxpro program.

4. Anthropometric measurements

Weight, height, midarm circumference, waist circumference, hip circumference, triceps skinfold thickness, subscapular skinfold thickness and suprailiac skinfold thickness were measured.

These measurements were then used to determine body mass index(BMI) and obesity rate(OR).

5. Biochemical analysis

Fasting blood samples were obtained from the subjects by venipuncture. RBC count, Hb and Hct were measured with Coulter counter(Coulter T 890 1994) to assess the iron status. Serum ferritin was measured with the I^{125} IRMA Kit using the two-side immunoradiometric assay(Addison et al. 1972).

6. Statistical analysis

Statistical analysis was done by using the Statistical Analysis System(SAS). Data were expressed as the mean ± standard deviation. The difference between the means before and after milk service program was analysed statistically by paired t-test at $\alpha=0.05$.

Results and Discussions

1. General chacteristics

The general chacteristics of the elderly is shown in Table 1. Fifteen subjects (36.6%) were within 75 – 85 years of age, fourteen subjects were within 65 – 69 years and the remaining 29.3% were within 70 – 74 years.

Twenty five subjects(61.0%) lived alone or lived with their spouse. Nineteen subjects(46.3%) had a household income of less than 20 thousand won which is below 66 thousand won, the minimum life expense required for a small city household as suggested by Park et al.(1994).

2. Changes of nutrient intake after milk supplementation

The mean nutrient intake before and after milk supplementation is shown in Table 2. The average intakes of all nutrients before milk supplementation were below the recommendations for their ages. The nutrients males consumed that amounted to less than the two-thirds of RDA(67% of RDA) were calcium and vitamin D as reported in many other studies(Park 1994 ; Park 1996). The calcium intake was 356.3mg(50.9% RDA) and vitamin D intake was 1.9μg(18.6% RDA).

Table 1. General Chacteristics N(%)

	Males (N = 9)	Females (N= 32)	Total (N= 41)
Age(yr)			
65 – 89	3(33.3)	11(34.4)	14(34.1)
70 – 74	3(33.3)	9(28.1)	12(29.3)
75 – 85	3(33.3)	12(37.5)	15(36.6)
Number of family(No.)			
1 – 2	7(77.7)	18(56.3)	25(61.0)
3 – 5	2(22.2)	13(40.6)	15(36.6)
≥6	0	1(3.1)	1(2.4)
Household income(1,000Won/month)			
≤100	0	7(21.9)	7(17.1)
110 – 200	5(55.5)	14(43.8)	19(46.3)
210 – 300	1(11.1)	6(18.8)	7(17.1)
310 – 400	1(11.1)	4(12.5)	5(12.2)
≥410	2(22.2)	1(3.1)	3(7.3)
Pocket money(1,000Won/month)			
20≤	9(100)	28(87.5)	37(90.2)
21 – 30	0	2(6.3)	2(4.9)
31 – 40	0	1(3.1)	1(2.4)
41 – 50	0	1(3.1)	1(2.4)
≥51	0	0	0
Education			
None	2(22.2)	19(59.4)	21(51.2)
Elementary	6(66.6)	9(28.1)	15(36.6)
Middle school	0	2(6.3)	2(4.9)
High school	1(11.1)	2(6.3)	3(7.3)
College	0	0	0

Females were taking most of the nutrients at a lower rate than those of males. They were taking 37.7g of protein(60% of RDA), 324.1mg of calcium(46.0% of RDA), 1.4μg of vitamin D(13.7% of RDA), and 0.7mg of riboflavin(59.2% of RDA).

The mean calcium intake of males significantly increased to 559.4mg(79.9% RDA), but the intakes of remaining nutrients were not significantly increased after milk consumption, which is probably due to much interindividual variation in nutrient intakes. The mean intakes of calcium, riboflavin and ascorbic acid of females were significantly increased after milk consumption. It is regarded that the abundance of calcium and riboflavin in milk partly contributed to the increase of their nutrient intake. The only nutrient taken below the two-thirds of RDA after milk supplementation was vitamin D.

Providing one cup of milk per day played a beneficial role in increasing the intake of nutrients, which are considered as the most deficient in the meal of Korean elderly to the amount higher than two thirds of RDA.

3. Changes of anthropometric data

Triceps skinfold thickness, suprailiac skinfold thickness, and waist circumference were significantly increased for males after milk supplementation(Table 3). Females showed significantly increased measurements of three kinds of skinfold thickness, waist circumference and hip circumference after milk supplementation.

It is regarded that the significant increase of anthropometric data is probably attributed to the added energy and protein of milk, even though the intake of energy and protein were not significantly changed.

4. Changes of bone density

There were no significant changes in the mean bone

density of lumbar spine, femoral neck, ward's triangle, and trochanter after milk supplementation. It appears that supplementation of one cup of milk for 10 months did not significantly increase the bone density (Table 4).

Ten months are probably not long enough to induce the change of bone density, considering the turnover rate of bone in the elderly is low or that calcium itself did not have any effect on the increase of bone density as reported in other studies(Riggs et al. 1987). Knowing that the bone density of the elderly is decreasing with age, nonsignificant changes of bone density means a cup of milk can play a role to prevent the decreasing of bone density. The proportion of osteopeina estimated by the T score of lumbar spine bone density was decreased from 50%

Table 2. Changes in the mean intake of daily nutrients after milk consumption

	Males(N=9)		Females(N=32)	
	Before	After	Before	After
Energy(Kcal)	1462.8 ±170.3[1)] (77.2)[2)]	1602 ±118.1[NS] (80.1)	1176.8 ±354.7 (70.3)	1240 ±352.3[NS] (72.9)
Protein(g)	48.8 ± 7.2 (69.8)	53.5 ± 15.5[NS] (76.4)	37.7 ± 12.0 (60.4)	41.0 ± 16.8[NS] (68.3)
Fat(g)	19.5 ± 5.0	24.5 ± 9.5[NS]	18.6 ± 8.5	22.6 ± 9.3[NS]
Carbohydrate(g)	257.7 ± 39.0	268.8 ± 82.6[NS]	210.3 ± 74.9	217.7 ± 60.7[NS]
Calcium(mg)	356.3 ± 88.8 (50.9)	559.4 ±104.8[*] (79.9)	324.1 ±103.5 (46.0)	520.7 ±164.9[**] (74.3)
Phosphorus(mg)	552.4 ± 83.1 (78.8)	651.8 ±120.3[NS] (93.0)	508.3 ±125.6 (72.7)	612.1 ±170.1[NS] (87.4)
Iron(mg)	11.0 ± 1.2 (91.5)	11.2 ± 3.4[NS] (92.9)	9.8 ± 2.4 (81.7)	11.6 ± 3.9[NS] (96.7)
Vitamin D(μg)	1.9 ± 0.6 (18.6)	1.9 ± 0.7[NS] (18.6)	1.4 ± 0.7 (13.7)	1.3 ± 0.7[NS] (12.9)
Thiamin(mg)	0.8 ± 0.2 (83.3)	1.0 ± 0.4[NS] (96.7)	0.9 ± 0.3 (86.7)	0.8 ± 0.3[NS] (79.7)
Riboflavin(mg)	0.8 ± 0.2 (69.9)	1.0 ± 0.3[NS] (99.8)	0.7 ± 0.2 (59.2)	1.2 ± 0.4[***] (96.9)
Niacin(mg)	11.3 ± 1.9 (79.0)	12.9 ± 3.5[NS] (99.5)	9.7 ± 3.6 (70.9)	11.0 ± 4.3[NS] (84.5)
Ascorbic acid(mg)	49.6 ± 9.8 (90.1)	50.8 ± 18.8[NS] (92.3)	41.2 ± 13.7 (74.9)	50.8 ± 19.3[*] (92.3)

1) Mean±SD 2) RDA percentage *p<0.05, ** p<0.01

Table 3. Changes of anthropometric indicators after milk consumption

Anthropometric indicators	Males(N=9)		Females(N=32)	
	Before	After	Before	After
Height(cm)	161.5± 5.4[1)]	160.6± 7.1[NS]	148.7± 5.2	148.6± 5.1[NS]
Weight(kg)	59.7± 9.5	60.9±10.3[NS]	52.6± 9.4	53.1± 9.6[NS]
Skinfold thickness(mm)				
Triceps	14.5± 7.5	20.0± 6.4[***]	20.4± 6.6	26.0± 8.0[***]
Subscapular	18.6± 8.7	20.2± 8.3[NS]	20.0± 6.9	24.4± 7.7[***]
Suprailiac	16.7± 9.5	23.2±10.3[***]	24.9± 9.5	27.7± 8.6[**]
Circumference				
Midarm	27.7± 3.8	27.9± 6.7[NS]	27.1± 3.2	27.1± 3.1[NS]
Waist	81.5±13.1	87.5±12.1[***]	80.5±10.2	83.9±10.0[*]
Hip	94.3± 6.8	98.5± 7.8[NS]	95.5± 8.5	98.2± 7.3[**]

1) Mean±SD 2) NS : Not significant by student's t test **p<0.01, ***p<0.001

to 34.6% and from 69.2% to 53.8% estimated by the femoral neck bone density for females. It appears that one cup of milk per day prevents the bone density from decreasing and at least lowers the proportion of osteopenia(Table 5).

5. Changes of iron status

The mean hemoglobin level was significantly reduced for males and the mean RBC count, hemoglobin, and the serum ferritin were significantly decreased after milk supplementation for females (Table 6). The proportion of anemia estimated by hemoglobin(<12 g/dl), Hct(<36%) and serum ferritin(<15ng/ml) were increased from 17.2% to 51.7%, from 20.7% to 44.8% and from 10.3% to 17.2%, respectively for females.

It seems calcium contained in milk reduced the iron absorption as reported by Hallberg et al.(1991). Calcium could probably induce iron deficiency by delaying the uptake of iron into the intestinal mucosal cells or by influencing the further transfer of iron from the cells into the circulation.

Because the elderly was encouraged to have a cup of milk right after lunch at the welfare center, it was regarded that the lowering effect of milk calcium on iron absorption was higher.(When the elderly were not told to drink milk at the welfare center, most of them saved the milk and took home for their grandchildren or other family member.)

The proper way to serve a cup of milk should be groped.

Table 4. Changes of bone density

Bone density	Males(N= 9)		Females(N=26)	
	Before	After	Before	After
Lumbar spine(L_2-L_4)(g/cm^2)	0.980±0.145	0.998±0.134[1)NS]	0.848±0.137	0.833±0.155[NS]
Femoral neck(g/cm^2)	0.769±0.150	0.758±0.126[NS]	0.614±0.105	0.560±0.097[NS]
WT(g/cm^2)	0.622±0.178	0.618±0.160[NS]	0.460±0.095	0.448±0.097[NS]
Trochanter(g/cm^2)	0.717±0.140	0.713±0.413[NS]	0.565±0.104	0.531±0.136[NS]

1) Mean±SD NS : Not Significant WT : Ward's triangle

Table 5. Changes in the proportion of osteopenia

Bone density	Male(N=9)			Female(N=26)		
	Tscore	Before	After	Tscore	Before	After
Lumbar spine(g/cm^2)	−1 ~ −2.5	5(50.0)	6(60.0)	−1 ~ −2.5	13(50.0)	9(34.6)
Femoral neck(g/cm^2)	−1 ~ −2.5	5(50.0)	4(40.0)	−1 ~ −2.5	18(69.2)	14(53.8)

Table 6. Changes in iron status

Hematological indicators	Males(N=9)		Females(N=29)	
	Before	After	Before	After
RBC count($10^{8/}/mm^3$)	4.4± 0.3	4.4± 0.4[1)NS]	4.0± 0.4	3.9± 0.4**
Hematocrit(%)	41.1± 4.0	41.1± 6.2[NS]	37.4± 3.6	36.5± 3.2[NS]
Hemoglobin(g/dl)	14.0± 1.5	13.0± 1.9*	12.7± 1.4	12.0± 1.3**
Serum ferritin(ng/dl)	62.3±45.0	29.3±16.1[NS]	65.4±46.9	31.4±25.7**

1) Mean±SD 2) *p<0.05 **p<0.01 3) NS : Not significant by student's t-test

Table 7. Changes in the proportion of anemia

Hematological indicators	Males(N=9)			Females(N=29)		
	Cutoff point	Before	After	Cutoff point	Before	After
Hemoglobin(g/dl)	<13	3(33.3)	4(44.4)	<12	5(17.2)	15(51.7)
Hematocrit(%)	<39	3(33.3)	2(22.2)	<36	6(20.7)	13(44.8)
Serum ferritin(ng/ml)	<15	0	1(11.1)	<15	3(10.3)	5(17.2)

Summary and Conclusion

The effect of milk supplementation on the elderly' s bone density and iron nutritional status was investigated. Forty one elderly subjects over 65 years of age (male : 9, female : 32) participated in the study. One cup of milk(200ml) per day was served with meal service at the wellfare center. The results are as follows.

1) The mean calcium intake of males significantly increased from 356.3mg(50.9% RDA) to 559.4mg (79.9% RDA). The mean intakes of calcium, riboflavin and ascorbic acid of females were significantly increased after milk consumption. The only nutrient taken below the two-thirds of RDA was vitamin D.

2) Triceps skinfold thickness, suprailiac skinfold thickness, and waist circumference were significantly increased for males. Females showed significantly increased measurements of three kinds of skinfold thickness, waist circumference and hip circumference.

3) There were no significant changes in the mean bone density of the lumbar spine, fermoral neck, ward's triangle and trochanter. But the proportion of osteopenia estimated by the T score of lumbar spine bone density was lowered from 50% to 34.6% and from 69.2% to 53.8% as estimated by femoral neck bone density for females.

4) The mean hemoglobin level was significantly reduced for males and the mean RBC count, hemoglobin, and serum ferritin were significantly decreased after milk supplementation for females. The proportions of anemia estimated by hemoglobin(<12g/dl), Hct(<36%) and serum ferritin(<15ng/ml) were increased from 17.2% to 51.7%, from 20.7% to 44.8% and from 10.3% to 17.2%, respectively for females.

It is regarded that providing one cup of milk per day played a beneficial role in increasing the amount of calcium to higher than two-thirds of RDA and can play a role in preventing the decrease of bone density due to aging. However, it adversely effected the indicators of iron status and increased the proportion of anemia especially for females. The proper way serving a cup of milk should be groped.

References

Addison GM, Beamish MR, Hales CN, Hodkins H, Jacobs A, Llewellin P(1972) : An immunoradiometric assay for ferritin in the serum of normal subjects and patients with iron deficiency and iron overload. *J Clin* 25 : 326-329

Cumming SR, Kelsey JL, Nevitt MC, O'Dowd KJ(1985) : Epidemiology of osteoporosis and osteoporotic fractures. *Epidemiol Rew* 7 : 178-208

Daniell N(1976) : Osteoporosis of the slender smoker. *Arch Intern Med* 136 : 298-396

Elders PJM, Netelenbos JC, Lipis P(1991) : Calcium supplemetation reduces verteral bone loss in perimenopausal women : A controlled trial in 248 women between 46 and 55 years of age. *J Clin Endocrinol Metab* 73 : 533-540

Hallberg L, Brune M. Erlandsson M, Sandberg AS, Rossander-Hulter L(1991) : Calcium : effect of different amounts on nonheme and heme iron absroption in humans. *Am J Clin Nutr* 53 : 112-119

Heaney RP(1987) : The role of nutrition in prevention and management of osteoporosis. *Clin Obstet Gynecol* 50 : 833-859

Kim KN, Lee JW, Park YS, Hyun TS(1997) : Nutritional status of the elderly living in Cheong ju-1. Health related habits, dietary behaviors, and nutrient intakes. *Korean J Comm Nutr*2(4) : 556-567

Park HR(1996) : Current Nutritional status by different age group. *Korean J Comm Nutr*1(2) : 301-322

Park MH(1994) : Nutritional status of Korean elderly people. *Korean J Nutr* 27(6) : 616-635

Park SI, Kim MG, Lee SY, Chung HT, Lee KS, Ha KW (1994) : A study on minimum life expense of the household. Korea Institute for Health and Social Affairs.

Pocock NA, Eisman JA, Hopper JL, Yeates MG, Sambrook PN, Elbert S(1987) : Genetic determinants of bone mass in adults : A twin study. *J Clin Invest* 80 : 706-10

Riggs BL, Melton LJ(1988) : Evidence of two distinct syndrome in involutional osteoporosis, *Am J Med* 75 : 899-912

Riggs BL, Wahner HW, Melton LJ, Richelson LS, Judd HL, O'Fallon WM(1987) : Dietary calcium intake and rates of bone loss in women. *J Clin Invest* 80 : 979-982

Smith EL, Giligan C, Smith PE, Sempos CT(1989) : Calcium supplementation and bone loss in middle aged women. *Am J Clin Nutr* 50 : 833-842

Son SM, Chon YN(1998) : The effect of calcium or 1α(OH) D_3 on the bone density and biochemical indices of eld-

erly with osteopenia. *Korean J Comm Nutr* 3(3) : 508

Son SM, Park YJ, Koo J, Mo S, Yoon HY, Sung CJ(1996) : Nutritional and health status of Korean elderly from low income, urban area and improving effect of meal service on nutritional and health status. - 1. Anthropometric measurements and nutrient intakes. *Korean J Comm Nutr* 1(1) : 79-88

Song YS, Chung HK, Cho MS(1995) : The nutritional status of the female elderly residents in nursing home. - 1. Nutritional and biochemical health status. *Korean J Nutr* 28(11) : 1100-1116

Stillman RJ, Lohman TG, Slaughter MH, Massey BH(1986) : Physical activity and bone mineral content in women aged 30 to 85 years. *Med Sci Sports Exerc* 18 : 576-580