Original Article

Serum Mineral Levels among Nepalese Living in the Southern Agricultural Terai Region

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Abstract

The physical status and serum mineral concentrations for people aged 10 to 68 years living in an agricultural southern region of Nepal were determined. Systolic (SBP) and diastolic blood pressure (DBP) for both sexes in the 10-14 year age group were low ($p < 0.05$, vs the other age groups) and those for the over 50-year-olds tended to be higher than the other age groups. The mean values of total proteins (TP) (8.6 ± 0.5 g/dl for males and 8.7 ± 0.6 g/dl for females) were high due to an increase of globulin (3.9 ± 0.4 g/dl for males and 4.1 ± 0.5 g/dl for females). More than three-fourths of the subjects of both sexes showed calcium (Ca) levels of 9.0-11.2 mg/dl and about 65% of them showed potassium (K) levels of 4.8-5.4 mEq/l. A significant positive correlation between DBP and serum K was observed ($p < 0.05$). Serum inorganic phosphorus (IP) correlated with age ($p < 0.001$) and body mass index (BMI) ($p < 0.001$). The serum Ca levels correlated with TP ($r = 0.31$, $p < 0.001$), albumin (Alb) ($r = 0.50$, $p < 0.001$), IP ($r = 0.31$, $p < 0.001$), K ($r = 0.32$, $p < 0.001$) and chlorine (Cl) ($r = -0.37$, $p < 0.001$). Cl was associated with TP ($r = -0.21$, $p < 0.05$), Alb ($r = -0.36$, $p < 0.001$) and IP ($r = -0.21$, $p < 0.05$). These results suggested that Ca intake for the subjects seemed to be insufficient although their serum Ca level was within normal.

Key words: Nepalese, serum proteins, serum minerals, blood pressure, agricultural Terai region

Introduction

To evaluate the health status of the people in Nepal and to help the improvement of their nutritional status, we conducted studies of food intake in a mountain area (Sherpa tribe),¹⁾ in an industrial region (Itahari district, Terai region),²⁾ in an agricultural region (Chitwan district, Terai region)³⁾ and serum nutritional parameters (Itahari district)^{4,5)} of Nepalese. We found that their food consumption was greatly influenced by food habits, food availability and socioeconomic conditions. However, as a result, they consumed large amounts of cereals, but very low amounts of animal origin food, which led to the supply of the main source of nutrients such as energy, carbohydrate and protein to be from cereal. This finding suggested that the high-carbohydrate diet might influence the serum lipid levels.⁴⁾ We

also found that the average percent saturation of serum transferrin (serum iron/total iron binding capacity ratio) tended to be lower with lower iron intake for the people in the Itahari and Chitwan districts.⁶⁾ Recently, many epidemiological studies have shown evidence of how dietary intake levels of calcium, potassium, inorganic phosphorus and sodium chloride are related to blood pressure and bone formation.⁷⁻¹³⁾ As there are few reports related to the nutritional status of the Nepalese, this primary study was conducted to determine serum calcium, potassium, inorganic phosphorus, sodium and chlorine levels of the people living in the Chitwan district of the southern agricultural Terai region where residents were self-supporting but lived on a low income. The results obtained are discussed to show the relationships among serum levels of these minerals and their dietary intakes and are supplied to assess the nutritional status of minerals for the subjects examined.

Methods

The subjects were a random sampling from among the general populace and consisted of over 50% of the population of

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a village in Khargual of the Chitwan district, in an agricultural district of the Terai region in southern Nepal. Fasting venous blood samples were obtained in the morning from apparently healthy subjects (89 males and 82 females) aged 10 to 68 years. Two anthropometric measures, height and weight, were measured for all subjects, and body mass index (BMI)(wt/ht² in kg/m²) was calculated.

Serum total protein (TP), albumin (Alb), calcium (Ca) and inorganic phosphorus (IP) were measured by the colorimetric method with clinical kits (TP, Alb, Ca: Daiichi Chem. Co., Tokyo; IP: Wako Pure Chem. Ind. Ltd., Osaka, Japan). Serum globulin (Glb) was calculated by subtracting the Alb value from the TP value, and the Alb/Glb (A/G) ratio was calculated. Serum sodium (Na), potassium (K) and chlorine (Cl) levels were measured by the ion-selective electrode method.

All results were expressed as mean $\pm$ SD and treated by Student's t-test. Pearson's correlation coefficients were used to examine the relationship between the variables.

Results

The physical status of the subjects is shown in Table 1. The mean height and weight for males in the 10-14 year age group were 139 ± 9 cm and 28.6 ± 5.2 kg, respectively, and those for females were 136 ± 8 cm and 28.7 ± 6.3 kg, respectively, which were considerably lower compared with the other age groups ($p < 0.05$, vs over 15-19 year age group) and the mean BMI levels were also lower than those in the other age groups. Systolic (SBP) and diastolic blood pressure (DBP) for both sexes in the 10-14 year age group were also lower than those in the other age groups ($p < 0.05$) and those for over 50 years old tended to be higher than the other age groups. The DBP for females in the 15-19 year age group was lower than that for males in the same year age group (74.3 ± 6.7 mmHg vs 81.1 ± 10.3 mmHg, $p < 0.05$).

Table 2 shows the serum mineral levels of the subjects. The mean values of TP and Alb for the 10-14 year age group were 8.2 ± 0.4 and 4.5 ± 0.2 g/dl for males and 8.8 ± 0.5 and 4.7 ± 0.2 g/dl for females, respectively (Table 2) which were higher than the former (males) (TP; $p < 0.01$, Alb; $p < 0.05$). The mean values

of Glb for males in the 10-14 year age group (3.7 ± 0.4 g/dl) were significantly lower than those for females (4.1 ± 0.4 g/dl, $p < 0.01$). There were significant differences between the sexes in the 10-14 and 15-19 year age groups for serum Ca and in the 15-19 year age group for IP. The mean Ca/IP ratio (2.1-2.9) and Na levels (140-142 mEq/l) did not differ between sexes (Table 2). As shown in Fig. 1, more than three-fourths of the subjects for both sexes showed Ca levels of 9.0-10.2 mg/dl. Significant statistical differences in serum K and Cl were observed between sexes in the same age group (K; 20-29 and 40-49 year age groups, Cl; 15-19 and 20-29 year age groups)(Table 2). The mean values of K for males (5.3 - 5.6 mEq/l) were higher than those for females (4.9 - 4.7 mEq/l, $p < 0.01$), whereas Cl values were lower in males (101 - 102 mEq/l) than in females (104 mEq/l, $p < 0.01$). As shown in Fig. 2, the frequency distribution pattern of the serum K levels for both sexes indicated levels of 4.8 - 5.4 mEq/l for about 65% of the subjects.

Table 3 shows the correlation coefficients between the physical parameters and serum mineral levels. There were significant positive correlations between age and blood pressure (SBP and DBP, $p < 0.001$), age and BMI ($p < 0.001$), SBP and DBP ($p < 0.001$) and DBP and K ($p < 0.05$). Significant negative

Fig. 1 Frequency distribution patterns of serum calcium contents of subjects, males (■) and females (□).

Table 1 Physical characteristics of subjects aged 10 to 68 years.

Sex (age group)	Subjects (n)	Height (cm)	Weight (kg)	Body mass index (kg/m ²)	Blood pressure [#]	
					SBP (mmHg)	DBP (mmHg)
Male						
10-14	17(13)#	139 ± 9	28.6 ± 5.2	14.7 ± 7.2	110.9 ± 7.1	71.1 ± 6.9
15-19	15	158 ± 7**	42.8 ± 5.7	17.2 ± 1.2**	122.9 ± 12.0	81.1 ± 10.3*
20-29	26	164 ± 7**	50.8 ± 5.6**	18.9 ± 1.4	129.7 ± 16.1	83.5 ± 8.4
30-39	12	163 ± 7**	50.4 ± 5.6**	18.1 ± 2.6	129.4 ± 12.4	86.2 ± 6.9
40-49	9	160 ± 8*	47.9 ± 3.7**	18.7 ± 1.7	124.0 ± 13.4	80.0 ± 8.1
50-68	10	162 ± 6*	50.9 ± 6.7*	19.5 ± 2.5	140.8 ± 17.0	83.4 ± 8.1
All	89	157 ± 12**	44.8 ± 10.0**	17.1 ± 2.3	126.3 ± 15.7	81.1 ± 9.3**
Female						
10-14	15(12)#	136 ± 8	28.7 ± 6.3	15.4 ± 1.8	110.8 ± 6.8	68.8 ± 6.4
15-19	16	152 ± 6	43.7 ± 4.6	19.1 ± 1.8	120.0 ± 6.4	74.3 ± 6.7
20-29	23(22)#	153 ± 5	44.6 ± 5.0	18.9 ± 1.5	127.3 ± 20.3	78.5 ± 10.1
30-39	12	151 ± 5	39.3 ± 4.6	17.4 ± 1.5	121.1 ± 12.7	80.5 ± 9.7
40-49	6	146 ± 4	38.9 ± 2.5	18.4 ± 1.4	123.3 ± 9.9	78.0 ± 7.6
50-60	10	151 ± 7	41.4 ± 8.7	18.0 ± 3.2	138.6 ± 14.9	84.4 ± 5.4
All	82	149 ± 7	40.0 ± 7.9	17.9 ± 2.3	123.4 ± 15.7	77.2 ± 9.2

[#]()Numbers express blood pressure (85 males and 78 females).

* $p < 0.05$, ** $p < 0.01$ (vs. female, same age group).

Table 2 Serum mineral contents of Nepalese aged 10 to 68 years.

Parameters	10-14	15-19	20-29	30-39	40-49	50-68	All
Males: number	17	15	26	12	9	10	89
Total protein (g/dl)	8.2 ± 0.4**	8.8 ± 0.4	8.7 ± 0.5	8.7 ± 0.4	8.6 ± 0.7	8.3 ± 0.5	8.6 ± 0.5
Albumin (g/dl, Alb)	4.5 ± 0.2*	4.8 ± 0.3	4.8 ± 0.2	4.8 ± 0.3	4.6 ± 0.2	4.4 ± 0.4	4.7 ± 0.3
Globulin (g/dl, Glb)	3.7 ± 0.4**	4.0 ± 0.3	4.0 ± 0.4	3.9 ± 0.3	4.0 ± 0.6	3.9 ± 0.5	3.9 ± 0.4**
Alb/Glb ratio	1.2 ± 0.1	1.2 ± 0.1	1.2 ± 0.1	1.2 ± 0.1	1.2 ± 0.2	1.1 ± 0.2	1.2 ± 0.1
Calcium (mg/dl, Ca)	9.6 ± 0.3*	10.2 ± 0.3*	10.0 ± 0.3	9.9 ± 0.6	9.8 ± 0.6	9.5 ± 0.4	9.9 ± 0.5
Inorganic phosphorus (mg/dl, IP)	4.6 ± 0.5	4.6 ± 0.7*	3.6 ± 0.3	3.7 ± 0.4	3.4 ± 0.4	3.5 ± 0.5	3.9 ± 0.7
Ca/IP ratio	2.1 ± 0.2	2.3 ± 0.3	2.8 ± 0.3	2.7 ± 0.4	2.9 ± 0.3	2.8 ± 0.4	2.5 ± 0.4
Sodium (mEq/l)	141 ± 2	140 ± 2	141 ± 1	141 ± 2	142 ± 2	141 ± 2	141 ± 2
Potassium (mEq/l)	4.9 ± 0.5	5.3 ± 0.5	5.3 ± 0.5**	5.3 ± 0.8	5.6 ± 0.7*	5.2 ± 0.5	5.2 ± 0.6**
Chlorine (mEq/l)	103 ± 2	101 ± 2**	102 ± 2**	102 ± 2	105 ± 3	104 ± 2	102 ± 2**
Females: number	15	16	23	12	6	10	82
Total protein (g/dl)	8.8 ± 0.5	8.8 ± 0.6	8.8 ± 0.7	8.6 ± 0.6	8.7 ± 0.4	8.7 ± 0.5	8.7 ± 0.6
Albumin (g/dl, Alb)	4.7 ± 0.2	4.7 ± 0.3	4.6 ± 0.3	4.6 ± 0.3	4.5 ± 0.3	4.5 ± 0.2	4.6 ± 0.3
Globulin (g/dl, Glb)	4.1 ± 0.4	4.1 ± 0.5	4.1 ± 0.5	4.0 ± 0.5	4.2 ± 0.3	4.3 ± 0.6	4.1 ± 0.5
Alb/Glb ratio	1.1 ± 0.1	1.2 ± 0.1	1.1 ± 0.1	1.2 ± 0.1	1.1 ± 0.1	1.1 ± 0.1	1.1 ± 0.1
Calcium (mg/dl, Ca)	10.0 ± 0.4	9.8 ± 0.4	9.7 ± 0.4	9.5 ± 0.4	9.6 ± 0.4	9.5 ± 0.3	9.8 ± 0.6
Inorganic phosphorus (mg/dl, IP)	4.6 ± 0.4	4.0 ± 0.6	3.6 ± 0.6	3.7 ± 0.6	3.3 ± 0.4	3.6 ± 0.5	3.9 ± 0.7
Ca/IP ratio	2.2 ± 0.2	2.5 ± 0.5	2.8 ± 0.5	2.7 ± 0.3	2.9 ± 0.4	2.7 ± 0.4	2.5 ± 0.4
Sodium (mEq/l)	141 ± 2	141 ± 2	141 ± 3	141 ± 3	140 ± 1	142 ± 2	141 ± 2
Potassium (mEq/l)	4.9 ± 0.4	5.0 ± 0.4	4.9 ± 0.4	5.0 ± 0.5	4.7 ± 0.5	5.2 ± 0.8	4.9 ± 0.5
Chlorine (mEq/l)	102 ± 2	104 ± 3	104 ± 3	104 ± 3	104 ± 3	105 ± 2	104 ± 3

Values are mean ± SD. *p<0.05, **p<0.01 (vs. females, same age group).

Fig. 2 Frequency distribution patterns of serum potassium contents of subjects, males (■) and females (□).

Fig. 3 Relationship between serum albumin and calcium concentrations for individual subjects, 89 males (●) and 82 females (○) ($r=0.34$, $p<0.001$).

Table 3 Correlation between physical parameters and serum mineral contents.

Parameter	Age	Blood pressure [#]		Body mass index
		SBP	DBP	
Age	1.00	0.45**	0.41**	0.35**
Blood pressure: SBP	0.45**	1.00	0.67**	0.20
DBP	0.41**	0.67**	1.00	0.21
Serum: calcium	-0.19	0.06	0.13	-0.13
inorganic phosphorus	-0.36**	-0.16	-0.08	-0.37**
potassium	0.05	0.08	0.24*	-0.04
sodium	0.17	0.13	0.06	0.09
chlorine	0.18	0.03	-0.13	0.12

[#]85 males and 78 females. *p<0.05, **p<0.001.

correlations between age and IP ($p<0.001$) and BMI and IP ($p<0.001$) were observed.

Table 4 shows the correlation coefficients for the serum parameters examined. There were significant positive correlations between TP and Alb ($p<0.001$), TP and Glb ($p<0.001$) and TP and Ca ($p<0.001$). Significant negative correlations between TP and the A/G ratio ($p<0.001$) and TP and Cl ($p<0.05$) were observed. The Alb level increased significantly with the A/G ratio ($p<0.001$), Ca ($p<0.001$, Fig. 3) and K ($p<0.05$), but decreased with Cl ($p<0.001$). The serum Ca level was also correlated with IP, K (Fig. 4) and Cl ($p<0.001$, respectively). IP showed a negative correlation with Cl ($p<0.05$) and Na ($p<0.001$).

Discussion

The mean weight was relatively low for the mean height of the subjects in this study and as a result, the mean BMI values ranged from 17 to 20 which were lower than those reported for teenagers (20-23),¹⁴ 11-18-year-old females (19-26)¹⁵ and 10-30 year age groups (17-18 for 11 years old and 20-26 for 16-, 23- and 33-year-olds).¹⁶ The BMI values for the over 30 year age groups in this study tended to be lower compared with those for the same age groups in an industrial district reported previously (20-25 for males and 22-24 for females).⁴

Table 4 Correlation between various serum parameters measured on the subjects.

Parameter	TP	Alb	Glb	A/G	Ca	IP	Ca/IP	Na	K
Total protein (TP)	1.00								
Albumin (Alb)	0.62**								
Globulin (Glb)	0.85**	-0.12							
Alb/Glb ratio (A/G)	-0.45**	0.42**	-0.84**						
Calcium (Ca)	0.34**	0.50**	0.10	0.16					
Inorganic phosphorus (IP)	0.14	0.09	0.11	-0.07	0.31**				
Ca/IP ratio (Ca/IP)	-0.10	-	-0.12	0.12	-0.05	-0.94**			
Sodium (Na)	-0.11	-	-0.12	0.12	0.02	-0.02	0.01		
Potassium (K)	0.19	0.21*	0.12	-	0.32**	-0.02	0.09	-0.10	
Chlorine (Cl)	-0.21*	-0.36**	-0.01	-0.16	-0.37**	-0.21*	0.13	0.59**	-0.15

* $p < 0.05$, ** $p < 0.001$. $n = 171$ (89 males and 82 females). Fig. 4 Relationship between serum potassium and calcium concentrations for individual subjects, 89 males (●) and 82 females (○) ($r = 0.32$, $p < 0.001$).

The mean serum TP level was higher than that reported in an industrial district (7.8 g/dl for males and 8.0 g/dl for females)¹⁾ and for young Japanese and Dutch (7.8 ± 0.5 g/dl for both)¹⁷⁾ The high TP level was caused by an increase in the Glb level because the mean Alb level was almost at the same level as those reported by others (4.7 ± 0.3 g/dl for Japanese and Dutch,¹⁷⁾ 4.5 ± 0.3 g/dl for Nepalese living in an industrial district⁶⁾). Such a high Glb level suggests the occurrence of chronic infection or chronic liver disease or multiple myeloma, which might be related to polio or malaria, very common diseases in southern Nepal.

The serum Ca levels for the subjects in this study were lower than those reported for Nepalese mothers and their infants living in an urban area of Nepal (10.7 and 10.4 mg/dl, respectively),¹⁸⁾ for the people in an industrial district of the Terai region (10.6 and 10.3 mg/dl for males and females, respectively)⁴⁾ and for young Japanese (10.5 ± 1.2 mg/dl) and Dutch (10.2 ± 1.0 mg/dl).¹⁷⁾ The mean values of Ca for the subjects were in the low-normal ranges of the Japanese (normal ranges for Japanese; 9.0-11.5 mg/dl) and the IP levels were higher than those reported for

Japanese (3.2 ± 0.4 mg/dl) and Dutch (3.5 ± 0.5 mg/dl),¹⁷⁾ which resulted in a lower Ca/IP ratio. Recently, dietary Ca is considered to be an important factor in relation to the prevention of cancer, hypertension, heart disease and osteoporosis. Increasing Ca intake increases bone mass Ca accumulation during childhood and adolescence and thus can reduce bone loss in postmenopausal women and in the elderly.^{12, 19-21)} There have been reports that serum Ca levels depend on the dietary intake of protein and Ca,^{22, 23)} but the level of serum Ca was not found to be associated with the dietary intake of Ca which was low.³⁾ Although this may be due to the homeostatic regulation of Ca levels in the blood, the fact that the mean values of Ca were at the lower portion of the normal range may be related to the insufficient consumption of Ca, and therefore, the Ca intake should be increased for the people in this study. The positive correlation between serum Alb and Ca coincided with that of another study.²⁴⁾

The levels of Na and Cl were within normal ranges for Japanese (134-143 and 99-107 mEq/l for Na and Cl, respectively). Serum K levels were at higher levels of the normal range for Japanese (3.5-5.4 mEq/l). There are many reports on dietary NaCl,^{25,26)} K, Ca and Mg in relation to blood pressure and hypertension.^{7-10, 27-30)} Dahl et al reported that the dietary Na/K molar ratio is an important determinant for the development of hypertension.⁷⁾ Diets with a lower Na/K molar ratio (high levels of K intake) showed a lower blood pressure even in salt-induced hypertension.^{7, 8, 31, 32)} The mean intake of NaCl for the people in this area was 9.2 ± 3.8 g/person/day³⁾ and the Na/K molar ratio in the diets was 1.8 to 1.9. No correlation between NaCl intake and blood pressure was observed.³⁾ Dietary Ca levels also affected blood pressure and low levels of Ca intake are associated more clearly with blood pressure,¹²⁾ however, no correlation between either dietary (data was not shown) or serum Ca and blood pressure was observed. The results may be due to the lower amount of NaCl intake in comparison with Japanese³³⁾ and Tibetan immigrants living in Nepal³⁴⁾ or the amounts of their exercising activity or the absence of obesity found in this study. These results show that there may be at least a latent deficiency of Ca and an improvement in the mineral status is needed.

References

- 1) Hirai K, Okuda T, Fukuwatari T. Observation of living of the Sherpa tribe in Nepal and their dietary survey. Rep Sci Living Osaka City Univ 1975; 23: 27-34.
- 2) Hirai K, Nakayama J, Sonoda M et al. Food consumption and nutrient intake and their relationship among Nepalese. Nutr Res 1993; 13: 987-94.
- 3) Ohno Y, Hirai K, Sato N et al. Food consumption patterns and nutrient intake among Nepalese living in the southern

- rural Terai region. *Asia Pacific J Clin Nutr* 1997; 6: 251-5.
- 4) Hirai K, Okuno Y, Nagata K et al. Nutritional survey on the serum status of lipid, protein, and calcium levels in Nepalese. *J Clin Biochem Nutr* 1990; 9: 205-13.
- 5) Hirai K, Takagi E, Okuno Y et al. The serum status of tocopherol and retinol and their relation to lipids in persons aged 10-72 in Nepal. *Nutr Res* 1993; 13: 369-78.
- 6) Ohno Y, Hirai K, Nagata K et al. Evaluation of the iron status in Nepalese living in southern Nepal. *Nutr Res* 1998; 18: 1847-55.
- 7) Dahl LK, Leitzl G, Heine M. Influence of dietary potassium and sodium/potassium molar ratio in the development of salt hypertension. *J Exp Med* 1972; 136: 318-30.
- 8) MacGreor GA, Smith SJ, Markandu ND, Banks RA, Sagnella GA. Moderate potassium supplementation in essential hypertension. *Lancet* 1982; 2: 567-70.
- 9) Casenmiller JJM et al. The effect of dietary sodium on urinary calcium and potassium excretion in normotensive men with different calcium intake. *Am J Clin Nutr* 1985; 41: 52-60.
- 10) Joffres MR, Reed DM, Yano K. Relationship of magnesium intake and other dietary factors to blood pressure: the Honolulu heart study. *Am J Clin Nutr* 1987; 45: 469-75.
- 11) Wardlaw G. The effects of diet and life-style on bone mass in women. *J Am Diet Assoc* 1988; 88: 17-25.
- 12) McCarron DA, Morris CD, Young E, Rouillet C, Driieke T. Dietary calcium and blood pressure: modifying factors in specific populations. *Am J Clin Nutr* 1991; 54: 215s-9s.
- 13) Dawson-Hughes B. Osteoporosis treatment and the calcium requirement. *Am J Clin Nutr* 1998; 67: 5-6.
- 14) Lazarus R, Baur L, Webb K, Blyth F. Body mass index in screening for adiposity in children and adolescents: systematic evaluation using receiver operating characteristic curves. *Am J Clin Nutr* 1996; 63: 500-6.
- 15) Ellis KJ, Abrams SA, Wong WW. Body composition of a young, multiethnic female population. *Am J Clin Nutr* 1997; 65: 724-31.
- 16) Power C, Lake JK, Cole TJ. Body mass index and height from childhood to adulthood in the 1958 British birth cohort. *Am J Clin Nutr* 1997; 66: 1094-101.
- 17) Ohno Y, Hirai K, Higuchi H. A comparative study of serum proteins, lipids, calcium and inorganic phosphorus between Japanese and Dutch university students. *Environ Health Prev Med* 1998; 2: 157-60.
- 18) Moser PB, Reynolds RD, Acharya D, Howard MP, Andon MB. Calcium and magnesium dietary intakes and plasma and milk concentrations of Nepalese lactating women. *Am J Clin Nutr* 1988; 47: 735-9.
- 19) Arnaud CD, Sanchez SD. The role of calcium in osteoporosis. *Annu Rev Nutr* 1990; 10: 397-414.
- 20) Jackman LA, Millane SS, Martin BR et al. Calcium retention in relation to calcium intake and postmenarcheal age in adolescent females. *Am J Clin Nutr* 1997; 66: 327-33.
- 21) Nieves JW, Komar L, Cosman F, Lindsay R. Calcium potentiates the effect of estrogen and calcitonin on bone mass: review and analysis. *Am J Clin Nutr* 1998; 67: 18-24.
- 22) Spencer H, Kramer L, Osis D. Do protein and phosphorus cause calcium loss. *J Nutr* 1988; 118: 657-60.
- 23) Nordin BEC, Polley KJ, Need AG, Morris HA, Marshall D. The problem of calcium requirement. *Am J Clin Nutr* 1987; 45: 1295-304.
- 24) Nordin BEC, Need AG, Hartley TF, Philcox JC, Wilcox M, Thomas DW. Improved method for calculating fraction in plasma: reference values and affect of menopause. *Clin Chem* 1989; 35: 14-7.
- 25) Kawasaki T, Delea CS, Barttler FC, Smith H. The effect of high-sodium and low-sodium intakes on blood pressure and other related variables in human subjects with idiopathic hypertension. *Am J Med* 1978; 64: 193-8.
- 26) Miller ZJ, Daugherty SA, Weinberger MH, Grim CE, Christian JC, Lang CL. Blood pressure response to dietary sodium restriction in normotensive adults. *Hypertension* 1983; 5: 790-5.
- 27) McCarron DA, Morris CD, Henry HJ, Santon JL. Blood pressure and nutrient intake in the United States. *Science* 1984; 224: 1392-8.
- 28) McCarron DA. Role of adequate dietary calcium intake in the prevention and management of salt-sensitive hypertension. *Am J Clin Nutr* 1997; 65: 712s-6s.
- 29) Abrams SA, Grusak MA, Stuff J, O'Brien O. Calcium and magnesium balance in 9-14-year-old children. *Am J Clin Nutr* 1997; 66: 1172-7.
- 30) Tobian L, Lange J, Ulm K, Wold L, Iwai J. Potassium reduces cerebral hemorrhage and death rate in hypertensive rats, even when blood pressure is not lowered. *Hypertension* 1985; 7 (Suppl I): I-110-I-114.
- 31) Itoh K, Kawasaki T, Uezono K. Relationship of dietary intake of sodium, potassium, calcium and magnesium to blood pressure. *Jap Soc Public Health* 1995; 42: 95-103.
- 32) Lind L, Lithell H, Pollare T, Ljunghall S. Blood pressure response during long-term treatment with magnesium is dependent on magnesium status. A double-blind, placebo-controlled study in essential hypertension and in subjects with high-normal blood pressure. *Am J Hypertension* 1991; 4: 674-9.
- 33) National Nutrition Survey: 1996. Section of Nutrition, Bureau of Public Health, Ministry of Health and Welfare. Daiichi Publishing Co., Tokyo.
- 34) Itoh K, Kawasaki T, Ogaki T et al. Nutritional investigation in the Tibetan immigrants living in suburban district of Nepal. *J Health Sci* 1993; 15: 21-7.